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SYMPOSIUM ON THE PURPOSE AND ORGANIZATION OF CHEMISTRY TEACHING IN HIGH SCHOOLS.

With this issue we begin the Symposium on the Purpose and Organization of Chemistry Teaching in Secondary Schools. The articles will continue to be printed through at least three issues. We hope there will be a free and open discussion of the views presented. The entire series will be published in pamphlet form.

I. BY E. P. SCHOCH,

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To begin with I wish to express myself as most decidedly in favor of having chemistry taught in high schools. Our civilization involves at least as much of chemistry as it does of any other science. Without a systematic introduction into this subject a man cannot make an intelligent application of chemical facts and principles to the problems of daily life, commerce, manufacturing, agriculture, mining, etc., and though a high school course in chemistry cannot train a boy to be a chemist —any more than a course in physiology could make a physician of him—yet it can give him a knowledge of facts and relations in the world of matter around him which may be the source of much pleasure and profit to him. These considerations would justify the teaching of chemistry to students who will have no further opportunity or occasion to study the subject. I would also urge the teaching of high school chemistry to students who will pursue the subject further in a college. Against this it is often urged that the student has to repeat his elementary chemistry in college—college professors claim the work is often not well done, and then is worse than not done at all. While it is true that students coming from affiliated schools find it profit-

able to repeat the work in the college, it is equally true that the benefit of a high school course is not lost thereby—to the contrary, the high school course gives the student an advantage over the students who begin chemistry in college that lasts far beyond the freshman course.

I have stressed the information value of chemistry, but I would not have it appear that I consider its value limited to this—in fact, I believe the most important object before the teacher of elementary chemistry is to make the course effective as a *training* course. This must be accomplished. Unless the course is effective in this way, it may degenerate into a vaudeville performance, or the reading of a story book. And I would not tolerate vague attempts at training which are based on the idea that the nature of the subject, or the performing of laboratory experiments, or the "formula-like" writing up of notebooks—that these have a training value. I want the conscious effort of a live teacher working with a carefully devised plan to make the course "rigorous." Probably he will be criticised for trying to make specialists, for being narrow, etc., but I am rather inclined to the opinion that such criticisms are likely to be indications that he is striving in the right direction.

To summarize: The high school course in chemistry should be primarily a rigorous training course, but the information gained in connection with the training makes the subject particularly desirable in high schools.

In connection with the question of organization, I consider the selection of the teacher as the most important task. Since the subject is in a state of rapid growth and since its pedagogy is not well worked out—in fact, the present method of teaching is questionable in many points—and since examples of good teaching in elementary chemistry are rare even in colleges, it requires the selection of a man well trained in the subject. This alone is not sufficient. Such a man must set himself at the task of planning his course and equipping his laboratory. This must be done with care, and requires much time. He must be allowed many free periods during the school session, and the best results must not be expected for several years. Under such conditions any intelligent man who has had a minimum of four collegiate courses in chemistry, who sets himself enthusiatically and continuously to the task of elaborating his course, who surrounds himself with many texts, journals, and information books on the

subject and *reads them,* who attends from time to time meetings of science associations or summer sessions of the great universities—such a man will make a great success in a high school, and he will be a blessing to the community in which he labors. Such a man may be depended upon to plan and equip the laboratory most effectively; and in this he should suffer no interference from principal or superintendent. The writing of text-books and the selection of the details of the course, even for the purpose of college affiliation, must be done by him if it is ever to be done well.

In proportion as these requirements are deviated from, the results obtained will be less satisfactory. The most harmful thing is the selection of a teacher who has no professional training, or rather who has had only one year or so in the subject. Yet teachers who have had enough training but who do not study the pedagogy of the subject frequently do very little better than those who have had less training. Occasionally teachers of either class do very fair work, it is true, but on the whole as long as they remain in either class they never *advance* the subject, or improve the present state of affairs, though such improvement is highly necessary.

The absence of any incentive to able men to remain permanently in *teaching* positions—such as higher salaries for high school "specialists"—brings about the present tendency for young men to teach the sciences, and then when they have, or might have, developed adequate ability to handle the subject, to enter some other profession or accept an executive position such as a principalship. Thus the schools lose the benefit of their experience. This evil, which operates in many secondary schools, retards the improvement of science teaching more than anything else.

To summarize: Get a person who *knows* chemistry, give him an opportunity to devote himself to his special subject, secure his services for many years, and he will attend to the organization of the subject as no one else can.

II. By Nicholas Knight,

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In the organization of a chemical department the teacher must ever be the central figure. He is the most important factor. Unless he is a person of the right sort and calibre, the work must inevitably prove defective. The old story of Mark Hopkins on one end of the log and a student on the other has often been overworked; and yet it contains the elements of a profound philosophy. A company of tourists recently traveled extensively through Europe and the far East. It was the testimony of many on their return that they received more from their association with one man who chanced to be a member of the party, than from the trip itself, although that was of great value. Before a single building was erected for the future Johns Hopkins, President Gilman secured a faculty of six members. Some of these went to work in improvised laboratories, even in back kitchens, and they soon made the young university known throughout the civilized world. The man is surely the most important part of the equipment. The famous professors in the German universities are not necessarily great teachers, as we understand the term; surely they are not drill masters, but they shine by their own light, and prove a great inspiration to the young life associated with them. The need is for someone who can inspire.

The teacher must have a sufficient training for his work, as he must aim to fill, and more than fill, the place to which he may be called. He must be broadly educated in order to get a true perspective, and to see the relation of his subject to other departments. Latin and Greek should be the sure foundation for his linguistic studies. He should have at least a reading knowledge of French and German, and possibly of Italian and Spanish. He should be familiar with the masterpieces of the literature of his native tongue. He should have an appreciation of art and music. He should know something of history, philosophy, and the social sciences. He should be well trained in mathematics. He should have a wide acquaintance with the material sciences, and should have pursued the subject of chemistry two or three years, under favorable conditions, or until he is able to be an independent worker, and to solve some of the problems by his own efforts. He should be a man of

character, in whom the students, and the public as well, can have implicit confidence.

It is probable that we are describing a man too high priced and too valuable for many a secondary school. But the greatest compensation is not the salary, but the consciousness of rendering society a valuable service, and expanding an inconspicuous place to greater dimensions. Much of the world's best work is poorly paid from a monetary standpoint.

It should not be forgotten that we are attempting to discuss ideal conditions and not those that are too often met. A young lady graduate of one of our colleges who went off to instruct the youth in a high school for a year, returned at commencement and said she had been teaching chemistry. The professor, somewhat surprised, replied, "I did not know that you had included the subject in your college course." She admitted that she had never studied the science, and added, in all seriousness: "But you know, professor, chemistry is an easy subject." An insufficient training is a serious detriment to efficient teaching. Solomon was doubtless thinking of chemistry when he asserted that a *little* learning is a dangerous thing.

In this age laboratory instruction should constitute an important part of the course in science. If there is no laboratory for the students, the instructor should keep this deficiency in his thought as a burden until this serious defect is remedied. We believe in most cases he can accomplish this, especially if he is such a teacher and personality as we have in mind and have been attempting to describe. He must remain in a position sufficiently long to gain an influence in the community, so that his reasonable requests may command a favorable hearing. Where the taxpayers are unwilling to bear the expense, he may resort to private subscription. A science teacher in one of our cities assigned different subjects to his students, to one oxygen, to another hydrogen, etc., to give an illustrated talk of fifteen to twenty minutes on each topic. The other members of the classes sold tickets of admission. It did not take very long to realize three thousand dollars from this method, with which he secured a fine equipment. Another teacher received subscriptions of from twenty-five cents to fifty dollars, and thereby secured a fund of twelve hundred dollars with which he fitted up one of the best chemical departments to be found in any secondary school in New York state. If after a reasonable

time the teacher should find that a laboratory equipment is not among the reasonable possibilities, we would advise him to seek another field of labor.

The purpose of the instruction. The teacher may be confronted by three classes of pupils: those whose days of training will end with the high school course, a group that may constitute the largest percentage of his class; those who will go to college; or those who will go to the college, university, or technical school, and who will follow chemistry as a profession. It will undoubtedly be necessary to treat all classes in the same way.

We would not recommend too much theory, and would not make the subject too quantitative or too mathematical, although the simple stoichiometric problems should have a prominent place. The science can and should be made attractive as well as profitable, and it can be so treated as to appeal to nearly everyone. *It should be made attractive at any cost.*

Possibly a good and comprehensive definition of chemistry is that it is the science of the composition of bodies. The student should learn the nature and the composition of Aristotle's elements, earth, air, fire, and water, and the sources of contamination of the water we drink and the air we breathe.

The attention should be especially called to those changes that are common facts of experience and observation. The daily changes in the animal body, the changes in burning fuel and lights, in bread making, in the manufacture of "soft" soap as it is still produced in the country, to a limited extent the changes of digestion, the changes of decay and fermentation, the chemistry of organic bodies, of both plants and animals. Those phenomena should be emphasized at first that possess a marked human interest, and the mind can be gradually led to the theories and more abstract conceptions of the science. It may happen sometimes that one will have an opportunity to observe changes that are not so common as those indicated. The writer was once in a locality containing numerous nodules of iron pyrites, and readily observed that the earth was abnormally warm in many places. It was easily observable that the nodules were oxidizing to iron sulphate, and heat was resulting by the process.

The history of chemical science is one of the most interesting chapters in the story of human progress. No science has

a greater wealth from an historical standpoint. The problems that seem so easy even to the schoolboy of to-day were slowly and painfully worked out, and engaged the best intellects of all the generations of the past. The chemists contributed their full share toward making the nineteenth century glorious. The history is a challenge to the heroic in student nature and will surely fascinate and meet a hearty response. An account of some of the more recent discoveries is not devoid of interest. The discovery of argon and other gases of the atmosphere by Lord Rayleigh and Sir William Ramsay, since 1894, and the greatest discovery in chemistry ever made by a woman, radium, can be profitably, even though briefly, considered.

Teachers err, possibly it is a fault more common to young instructors, in using too difficult a text-book and making the subject too hard at first and too remote from the students' experience. A text-book not too difficult can easily be supplemented, as occasion may require. It is never wise to shoot above the head of the average pupil, and this is not an uncommon mistake.

What a world of application chemical science possesses! It is not usually a hard problem to interest the student along industrial lines. Fortunate, if the school is in reasonable proximity to a blast furnace, a soda ash plant, a glass or soap factory, a manufactory of chemicals, or a pottery works. Enthusiasm is at a high pitch as teacher and class visit an industrial plant to see how the simple principles learned in the text or the test tube are utilized on the large scale in some important industry. He begins to see the relation of his study to the great industrial world outside, and his "interest" is aroused which has such an important bearing on his "education."

Our experience after having taught in an imperfect way a number of the sciences and other subjects, has been that it is easier to arouse and maintain an interest in chemistry than in any other department of human knowledge; and that many a wayward boy has become interested in the subject, and has discovered himself and his own possibilities. He has thus been reclaimed from a life of idleness or crime, contributing his little mite to humanity's progress and the world's civilization. Such an opportunity in the hands of the skillful and tactful, of those who realize that the most valuable asset in this world is character, may become an incalculable power for good.

A knowledge of the material universe and the laws which govern it ought to make of anyone a better citizen and a more useful member of society. Such knowledge has contributed to the wealth of the world, and civilization rests first of all upon the material well-being of the race.

III. By Horace G. Byers, Ph.D.,

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I hold two propositions in this connection to be almost axiomatic. The chief object of the first year's work in chemistry in the high school is not the preparation of the student for college, neither is it to make chemists of the high school graduates. If these propositions be not self-evident, to make them so one need only call attention to the very small percentage of high school students who enter upon advanced work and to the fact that a working knowledge of chemistry cannot be gained in one year by persons much more mature than high school students, even though all available time be spent upon the subject. The query then is, what is the object to be sought by the instructor? In answer, three things stand out prominently as I view them: an introduction to a new phase of natural science; an acquaintance with a field of applied science; a training in the handling of the scientific method. These objects may be well associated together without overdoing that worthy thing, making the subject practical, without loading the student with a mass of fact and detail, which even if made very interesting is certain to be dissipated and lost in a very short time after the course ends, and without presenting a philosophical treatment, which the students are not prepared to assimilate. Most elementary teachers in my opinion err in one or the other of these directions.

Broadly speaking, the course should be what is ordinarily called descriptive chemistry. However, this is not to be interpreted as recommending the infliction upon the student of a huge mass of more or less orderly arranged facts concerning specific gravities, critical temperatures, molecular weights, and chemical equations. According to my view it should be a presentation of the fundamental chemical laws as they are at present stated—a presentation of the fundamental theories as

at present held. This presentation should be accompanied by sufficient historical treatment to give the student a sympathetic insight into the processes by which nature's secrets are ferreted out and by only sufficient minutiæ of detail to render the meaning of these fundamental principles clear.

It does not follow that such a course would result in an elaborate history of the development of chemistry. This preliminary treatment should then be followed by a systematic presentation of the application of these principles to industrial purposes and wherever possible by visits to industrial plants where these applications may be seen. It is not at all essential that such plants be those of *chemical* industries. Such establishments as foundries, flour mills, water systems, ice plants, paint shops, canneries, creameries, the operations of house painting, plastering, foundation construction, and household economy, can be made to yield illustrative material which will be equally useful with that obtained from a study of smelters, gas plants, breweries, dye works, etc.

The net result of a year's instruction in chemistry should be the development of a capacity to appreciate and feel an interest in the current literature referring to the subject and to appreciate how intimately chemistry touches us at all vital points. But above all the course should leave the student mentally stronger and more able to cope with the next task involving the use of the methods by which scientific generalizations are arrived at and in which applications of the generalizations are made to special instances. In other words, the course should strengthen the ability of the student to handle the scientific method in dealing with other problems which may present themselves.

In stating the above propositions in outline form, I have kept in mind the limitations imposed by the series of which this article is to form a part and have not attempted to give illustrations of how history, generalizations, and experimental facts may be combined to produce the results mentioned. However brief my outline on the subject may be I should not like to close without making a protest against a too prevalent method of dealing with chemistry, a method which leaves upon the student the impression that chemistry should properly be defined as the science of symbols and equations, which makes him feel triumphant when he can write the formula for microcosmic salt

and can give the equation for the reaction between potassium permanganate and hydrogen peroxide—if he ever reaches such a period—but which leaves him ignorant of the real significance of the formula and the purpose of the equation. Symbols, formulæ, and equations are the tools of the trade and are not to be elevated into the place of objects of study. I also urge a fervent protest against the teaching of the laws of science as mandatory upon nature's facts instead of as expressions of our knowledge of the facts.

Finally I would also register objection to the too prevalent presentation of formulative hypotheses as established facts. For example, it is neither desirable nor correct to present the hypotheses of Dalton or of Arrhenius as established, not so much because we may or may not have doubts as to their correct expression of our knowledge of the facts as because such presentations of these hypotheses is a misapplication of the scientific method and gives the student a distorted view of the relative importance of fact and theory.

MAKING A CHEMICAL COLLECTION.

By Wilhelm Segerblom,

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(*Continued from April issue.*)

Elements.

Each common metal should be shown so far as possible in all the different forms, such as sheet, wire, powder, ribbon, mossy, granular, dust, bar, foil, ingot, and native. Mossy lead may be made by melting old lead pipe in a blast lamp flame and allowing the melted metal to fall into water. The mossy lead thus made should be rinsed with hot water and allowed to dry quickly of its own accord to prevent oxidation. Tin bullets may be made in a similar manner. Silver buttons and precipitated silver may be worked up from the silver residues that collect in many laboratories. Precipitated metals may generally be made by immersing strips of zinc in solutions of their salts. Gold leaf and foil should be passe-partouted between glass plates for convenience in handling and to bring out the green color by transmitted light. The common forms of iron should be accompanied by native iron, by meteorites, and by etched slabs

of meteoric iron, showing the Widmanstatten figures. Sodium and potassium may be shown under kerosene; they should also be sealed in glass tubes in an atmosphere of hydrogen, so as to retain their color and luster.

Oxides.

More specimens can be obtained for this group than for any other of the groups of compounds. Oxide of silicon should be shown in chemically pure state as made from silicic acid; ordinary sand should be added; the number of varieties of quartz obtainable will probably depend upon the funds at hand. The following varieties should be shown both massive and polished: agate, opal, jasperized wood, tiger's eye, pudding stone, and rose quartz. The more characteristic iron ores should be included, even though part three of the collection may contain iron ores in connection with the extraction of iron therefrom.

Hydroxides.

Bauxite and brucite are the commoner mineral forms of hydroxides. The hydroxides of the heavy metals may easily be made from solutions of their salts, by precipitation with sodium hydrate or ammonia, the latter being preferable on account of the ease with which any excess thereof can be gotten rid of.

Hydrides.

Only two hydrides, phosphine and ammonia gas, are worthy of a place in the collection.

Chlorides.

Sodium chloride should be represented by as many different varieties as possible. Other chlorides may be represented by only one variety each. The common chlorides should be exhibited in twelve-ounce bottles, the less common chlorides in four-ounce bottles. Arsenic chloride and phosphorous penta-chloride should be kept in sealed glass tubes. The chlorides of silver, potassium, and sodium should be shown native.

Bromides.

Only eight or ten bromides need be shown. The common ones will suggest themselves. Since potassium bromide crystallizes exceedingly well, the large crystals showing cubical habit should be picked out and shown by themselves.

Iodides.

Four or five iodides should be sufficient—those of Na, Ag, K, and Pb; the last should be shown in recrystallized as well as amorphous form.

Fluorides.

Cryolite, barium fluoride, sodium fluoride, and calcium fluoride are sufficient. The last named should be illustrated by several specimens, because of its beautiful crystalline form.

Cyanogen Compounds.

Cyandies of K and Ag, sulphocyanides of K and NH_4, and ferricyanides of K and Fe should be shown. Ferrocyanides of the more common metals may be made in the laboratory by precipitation.

Sulphides.

Sulphides of the metals usually obtained in qualitative analysis may be precipitated from the salt solutions and kept under the same solutions in tall stoppered foot test-tubes to prevent oxidation. The more common commercial sulphides should be shown, particularly antimony sulphide, zinc sulphide, and iron sulphide; also calcium sulphide, both the common and the phosphorescent varieties. Ammonium sulphide with its three colors may be made in the laboratory. The sulphides and allied compounds occurring as minerals are so varied and numerous that a judicious selection must be made. The following should be shown: galena, sphalerite, stibnite, cinnabar, and the sulphides of copper and of iron. The last named might well be shown massive, crystalline, radiated, and, if possible, as separate cubes.

Carbonates.

Calcium carbonate should be shown in as many distinctly different forms as possible, crystalline forms being included. Of other mineral carbonates those of Ba, Sr, Mg, Cu, and Pb are most interesting. Commercial forms of the carbonates of the alkali metals and alkaline earth metals should be included.

Sulphates.

Of the mineral sulphates those of Ba, Sr, Pb, and Ca are most interesting. The last named should be illustrated by numerous specimens, for instance, anhydrite, satin spar, gypsum, and separate perfect crystals of selenite. Commercial sulphates of all the common metals are easily obtainable. Double sulphates such as alum, chrome alum, iron alum, and nickel-ammonium sulphate should be added. Several sulphates recrystallize easily and well, notably copper sulphate, alum, and chrome alum. These recrystallization experiments appeal strongly to the student mind. If strings are hung in the solutions the crystals form

easily, sometimes forming twins. Alum forms regular octahedra when the crystals are small; larger crystals of alum are often so modified as to appear hexagonal. Recrystallized efflorescent sulphates must be kept in stoppered bottles. The writer has succeeded in making a separate chrome alum crystal an inch and a half in longest diameter by repeated nursing of an octahedral chrome alum crystal from fresh solutions; it was necessary after each nursing to sandpaper off the secondary octahedra that persisted in growing out from the sides of the larger crystal. Anhydrous sulphates of the commoner heavy metals may be made quite easily by exposing thin layers of the crystallized salts to the air in a warm place.

Silicates.

Next to the oxides this forms the largest group and consists almost entirely of mineral specimens. Judicious selecting must therefore be practiced. The following should be selected first: varieties of mica, of felspar, of beryl, of tourmaline, of garnet; also talc, soapstone, and serpentine. Others may be added as desired. Black and red varieties of tourmaline should be shown, the latter both polished and rough. Garnet should be shown massive, small crystals occurring in matrix, small, separate crystals, large, separate, native crystal, and single, polished crystal showing dodecahedron form.

Potassium silicate and sodium silicate, both solid, should be purchased; so should sodium silicate syrup. From this syrup and soluble salts of twenty or more common metals one may precipitate the metallic silicates; these may not have a constant or definite composition, but they are interesting as showing the separate silicates that go to make up the complex silicates which have been mentioned above and which are present in such enormous quantities in the earth's crust. The precipitated silicates are in many cases extremely gelatinous and it is therefore necessary to make an extremely dilute solution of the metallic salt, preferably in a crock holding several gallons, and adding thereto a very dilute solution of sodium silicate syrup. These must sometimes stand several days before the clear liquid can be decanted. Filtration should be resorted to only when the liquid has been reduced by decantation to the smallest possible amount.

Oxalates.

The oxalates of about two dozen metals may easily be made in the laboratory. Those of the alkali metals may be made

by neutralization of oxalic acid with the alkaline hydrates. The others may generally be made by precipitation from the metallic salt solution with ammonium oxalate. Oxalic acid may well be added. This may be made from starch and nitric acid. Both ferrous and ferric oxalates may be included, but the latter must be protected from the light, because the beautiful green crystals change extremely readily to the yellow ferrous oxalate.

CHROMATES.

The soluble chromates might well be purchased, though those of Na, K, and NH_4 may be made by neutralization. Other chromates may be made by precipitation. Lead chromate is the only interesting native chromate. Bichromates of Na and K may be included. A conspicuous specimen of the last named may be made by repeated nursing of a single crystal hung on the end of a stout string. The result is a spherical mass several inches in diameter covered with bright red, highly lustrous, tabular crystals. Such a mass of crystals should be supported on a small glass crystal pan to avoid breaking the crystals. Attempts to coat balls of various material with potassium bichromate crystals failed to give satisfactory results.

NITRATES.

Nitrates of all the common metals are easily procurable. Since potassium nitrate crystallizes exceedingly well, it should be possible to get hexagonal crystals an inch or so in diameter. What was said under chlorides in regard to bottles applies generally to each group but particularly to the nitrate group.

PHOSPHATES.

This group may be limited to twelve or fifteen specimens. Sodium phosphate, microcosmic salt, phosphoric acid, turquois, and calcium phosphate suggest themselves first. The last named should be shown in precipitated form, as phosphate rock, and as the beautifully crystallized apatite.

MISCELLANEOUS COMPOUNDS.

This group may contain all those compounds not included in preceding groups, such as acetates of Ca, Cr, Cu, Pb, and Na. Paris green, chlorates, bromates, and iodates of K and Na, borax, tartar emetic, cream of tartar, Rochelle salts, iron ammonium citrate, and one or two specimens of each of the following: permanganates, arsenites, arsenates, nitrites, tungstates, molybdates, carbides, sulphites, and thiosulphates.

Arts and Manufactures.

This division of the collection was described briefly in the early part of this article, and under "classification" the general statement was made that this division should consist mainly of specimens illustrating those industries in which chemical reactions play an important part. Let it be added here simply that the different kinds of glass, porcelain, and crockery, together with their manufacture, should be illustrated. In almost every town it will be possible to get specimens illustrating the manufacture of illuminating gas. Metallic ores may be shown in considerable quantity and variety, and so far as possible the extraction of the metals from the ores should be illustrated. Electrolytic products and products of the alkali industries will bring the collection up to date. Specimens illustrating the manufacture of sulphuric acid are always of interest; so are specimens illustrating the various uses of carbon. Students coming from the coal regions are often ready to donate specimens showing the different stages in coal mining. A few organic substances should be included, such as a few alcohols, oils, organic acids, sugars, and starches. Petroleum compounds and analine dyes would not be out of place. Organic compounds suggest a few food products, but here the teacher must choose for himself. Since the crystalline forms of technical chemicals and of minerals in the first two divisions of the collection are seldom geometrically perfect, but are rather modifications of the theoretically perfect crystals, it will be exceedingly helpful to the student if a set of about twenty models of the common forms of crystals are shown; they should preferably be made of solid crystal glass, highly polished and at least two inches in length. The more complicated models made of glass plates and showing the axes are too confusing for the elementary student. Though the collection is strictly chemical in its nature, the third division might properly include a limited amount of material illustrative of the other natural sciences, particularly if the school in question does not already own a museum containing such specimens. By extension, therefore, this division might include a few specimens to illustrate various earth movements and other formations studied in geology. A few samples of plant fibres would interest students of botany. An exhibition which never fails to attract attention is a set of American woods such as those published in section form by Romeyn Hough of Lowville, N. Y. These

are of particular interest at present on account of the widespread interest in forestry.

In Conclusion.

A collection developed along the lines laid down above will be largely of exhibitive value. Many of the specimens, however, should be taken into the lecture room and passed to the members of the class for personal examination, because it is a recognized fact in natural science work that a student becomes better acquainted with those substances that he can actually handle.

The curator should keep a careful record of all additions to the collection, preferably in card catalogue form. The time and funds ordinarily at the disposal of the secondary school teacher preclude the possibility of compiling and publishing a printed catalogue of the collection. About a year ago the writer published such a descriptive catalogue of the collection that it has been his privilege to develop, and he has a limited number of these catalogues still on hand; he will be pleased to send a copy of this catalogue to any teacher who feels that it might aid him in building up a collection for his school.

One word of caution, please, as to a danger which has threatened the writer and which is pretty sure to threaten any teacher who starts a collection: *do not crowd specimens in the cases.* When shelf room is scarce and the specimens multiply, the teacher is strongly tempted to try to show all the specimens, and if this is done in insufficient cases the specimens themselves are impaired in value, the dignity of the collection is lost, and its effect upon the pupil and visitor is far from the desired object of the collection. Far better is it to keep newly acquired specimens packed away until suitable cases may be procured. Let it also be added that the arrangement of the specimens on the shelves is often of equal value with the specimens themselves; for that reason they should be arranged as artistically as their classification will allow and the harmonious appearance of the whole should constantly govern the arranging. By all means let not such a collection as here described parade before the visitor a cold, lifeless, strictly scientific classification, but rather let it stand as a monument to a happy combination in the teacher's mind of orderly arrangement and a human, artistic touch.

PRACTICAL SUGGESTIONS AS TO WAYS OF IMPROVING THE MATHEMATICAL PRODUCT OF THE HIGH SCHOOL.*

By Effie Graham,

Topeka High School.

I would not be a true follower of the unknown quantity did I not believe that the only way to improve the mathematical product of the high school is the way by which any product may be improved, that is by eliminating its zero or negative factors and substituting for its fractional factors real integral ones. We may disagree as to the relative or absolute value of the factors but we must all admit that the rule will solve the problem, the merest statement of which we shall now undertake. What is the matter, not with Kansas, Will White has settled that, but with our high school mathematics? Many other wise good teachers shorten the radius of the circle of their self-satisfaction and complacently say, "I see nothing seriously wrong with it now. I pay no attention to what others think about results in my department. I am training for power." Others, more progressive, going out on a tour of inspection to colleges, schools of technology, offices and business houses find that the results of the four years' work in our high school mathematics are not what under wiser rule they might become. No need to say this is true of all other branches. That is not the question. It certainly should not be true of our own.

Granted, then, that the product should be improved, the first thing we need is to eliminate the zero factors. Ask the average teacher to teach something in a certain term not heretofore required, and invariably the answer is, "I have no room for it. There is already too much to do in the time." There is no doubt of the truth of this; there is too much to do. Cut some of it out. Lack of quantity has never been the trouble; there is too much that lacks the excuse of future need or cultural value. What to eliminate is not mine to say, but we may consult and inquire and inform ourselves, then eliminate the things not really necessary for future work or present drill. A zero factor has no greater destroying power in a mathematical product than have these dead, useless, unrelated things in our high school product.

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*Read before the Kansas Mathematical Association.

There are also in our mathematical course factors of fractional value. They are perhaps cultural but not practical, or practical but not cultural. Needing time and room as we do, why not substitute for these something both practical and cultural? Long lists of dull problems in simultaneous equations or many of the so-called literal equations in algebra might well be replaced by lists of physics formulæ. Omit three or four dozen quadratics where x and y are the unknown quantities, substituting those in which the pupil must determine on sight whether the equation is a quadratic or a linear in R, S, or V. Write the equations yourself if you do not find a suitable text. Take out a few of the problems in which tardy "B starts to overtake A" and teach the pupil to recognize the quadratic equation if written in Gaelic, and to solve it by the formula even if blindfolded and with hands tied behind his back.

Having made room for them, let us see to it that some of the newer things in mathematics get into our classes. One of the very best ways to do this is to join the Kansas Mathematical Association and subscribe for a real live mathematical magazine. SCHOOL SCIENCE AND MATHEMATICS is one of these. The best talent of our country is now represented in these publications. Inspiration, information, direction, and guidance will come to us from this source. Even if we disagree in part we are at least awakened.

Giving the history of mathematics a part in the class room work in the proper amount and place is a marvelous interest awakener. Pupils for the first time realize the dignity of the text when learning of its classic value. They learn that the handbook of Ahmes, 1700 B. C., contained a problem in arithmetical progression; that Euclid proved long ago that all angles are right angles, the fallacy of which many of them are unable to detect. These things captivate the wandering interest and create a renewed vigor in the solution of all problems. In the higher institutions of learning some of the best work in mathematics to-day is done by students who attribute their success to their suddenly awakened interest in mathematics by work of this kind done in a high school. Try it. Why not cast out ninety and nine problems in x, y, and z in order to gain one really awakened student? Organize a mathematics club to meet after school hours or evenings and study the history and the development of mathematics, its fallacies, famous problems, etc., and

watch results. Notice the smile that greets the statement then, that even the Egyptians could solve a quadratic.

These are only suggestions. There are many new old things in use to-day in high school; the graph, having its place as an illuminant of the quadratic, and laboratory methods, a name more formidable than suggestive. You are all familiar with these, and I only need to say, "Make room, take out the zero factors, the half value things, and substitute either those of integral value or those that will add interest to the making up of our mathematical product."

I like the idea that our high school mathematics class room ought oftener to be our mental laboratory, a place where we do things mentally; where keen thought, vivid imagination, shrewd phrasing of an abstruse proposition, nice discrimination of thought differences, have place, scope and encouragement, the teacher saying openly and frankly, "Now this is mental gymnastics. Value it, solely because it teaches you to think carefully and correctly." In geometry, "This lesson to-day is as fine a vehicle for logic as you will find when you study logic itself," or in algebra, "This is a lesson in the translation of English into algebraic symbols. Let there be no solving problems to-day; let all think, strive to express the shades of English meaning in the much desired equation." A little of this mental laboratory work, even if we neglect to find the G. C. D. by the division method, will send a class out with their heads in the air, conscious and proud of their mentality and anxious to do anything that will aid in its development.

At one time, at the original New York Chautauqua, it was the privilege of the speaker to see the Rev. Lyman Abbott arise to address an audience of eight thousand people. His subject was not announced but it was expected that he would speak on one of the many philosophical subjects of which he is master. Standing for several minutes without speaking, surveying the multitude, he said, "Friends, you may or may not sanction my action, but I never face such a crowd as this without remembering that first of all I am a preacher of the Word, a minister of the gospel, and so I shall to-night preach a straight gospel sermon." And such it was. No metaphysical flights nor rhetorical periods, only the straight sweet gospel story.

It is not sacrilegious to use this story to illustrate my point: for to me, the mission of a teacher, even of a teacher of mathe-

matics, is clearly high and helpful. While unlike the Reverend Abbott I am not thrusting aside any eloquent exposition, still like him I have a story, my gospel of the mathematics teacher, new neither to you nor to me, and lacking even the charm of rare telling. It is told often now even where two or three mathematics teachers are gathered together. Every day and every hour the fact is brought anew and with greater force to my consciousness that the "water tight compartment" method, as some call it, of serving up our algebra, geometry, arithmetic and trigonometry is all wrong. One book is studied, closed and sealed with a great seal "which is never to be opened till the great day;" another subject is taken up, studied, closed and sealed in like manner, and so on until the last one in the course has been taken up and finished. We all know the result; our pupils, as J. N. Rice in those old Forum articles said, do not *know things*. They know the last term's work fairly well but not much preceding that. Oh, yes, our pupils have the power; they have gained power and that is the great end and aim of education. Granted they have gained power of a certin kind; why not the power to call up at will on being confronted with a problem its arithmetical, algebraic, or geometrical prototype, with its attendant solution?

Meeting something strange or new in the science, English or mathematics work in high school and college or in the problems of the business world, our pupils would not say if they were rightly taught, "I have never heard of that," or, "We used to do that in the eighth grade in geometry or algebra, but I have forgotten all about it." What greater manifestation of the power we hope to impart than that pupils are able to discover quickly in new problems something of which the old one was but a prototype, and be able to apply quickly and accurately their previous knowledge to its solution? Power to work is not enough to expect. Power to take the initiative, to know how to begin, how to go on, is what we must have, otherwise we may say that something is the matter with our high school mathematics.

How to do this? You are all working this out, I hope. Will parallel courses of arithmetic, algebra and geometry do it? I believe that they will do much. It is a success abroad. Failures in this country have been the result of faulty application and present environment rather than of the plan itself. It is a

psychological fact that time and repetition are necessary elements in burning facts and methods into the memory and consciousness until the doing becomes mechanical. A boy who solves one equation a day for three hundred and sixty-five days will never forget the method; while the fellow who solves three hundred and sixty-five equations in ten days may do so. The last day before graduation a pupil should if rightly taught be able to recall without effort the important things taught him in the eighth grade. Why not? Is not our joke about his being unable to do so rather an excuse for our failure than a justification of the fact?

Just now we ask, "When may we hope for better things?" We come up here year after year, listen, talk, agree, disagree, go home and do things in the same old way. Why not take some measures to rectify what most of us agree is an evil? A suitable text in algebra containing modern practical problems, work in graphs, with emphasis placed on the right topics for high schools and all other topics omitted would be a great thing for our high school mathematics; not a book made to sell to colleges, normal schools, private and country schools, large enough to fit the largest and to be cut down for us. Speed the day when the Kansas Mathematical Association will stand up to be counted when a text-book of algebra is chosen.

It would be another great thing for us if the Kansas colleges would agree upon a clear-cut, definite requirement for college entrance. When the subject of college algebra may cover everything from calculus to the catechism, and a dignified college professor clothed with authority and learning may say, "Teach this for entrance or that for smooth sailing next term in my class," and when another whose college flies a pennant of another color, but who is equally wise and equally learned, says, "Not that; that belongs in college. I wish you to teach something else;" and a third requires another different preparation, please tell us just where the poor high school product or the poorer producer is? The Kansas Mathematical Association hopes to see this remedied. We are uncertain as to the outcome of some policies, but we do know that here is a tribunal that will in time settle this among other anomalous things. Our Kansas colleges will be asked to furnish definite, clear and uniform requirements in high school mathematics, and at least a week's notice of a change in the course.

While we must have uniformity and intelligent supervision to do the best work, still wherever unhampered by uninterested and ignorant authority, let us take up the work ourselves and do what we may toward unifying the course. If alternate days' work in algebra and geometry is not satisfactory, and we are not yet convinced that it is unsatisfactory, it is within the power of every teacher to arrange her daily program so that into each recitation aside from the daily progress made in the new subject under consideration may be introduced some review of arithmetic, algebra or geometry. Some drill in rapid multiplying, adding, and the practical arithmetical processes, in solving quadratic equations, factoring, some work in exponents, computing triangles, etc., etc., not in a haphazard way, but outlined to cover gradually the whole course so that there is always present this idea of preserving the factors that were in the product when it came to us, as well as adding new ones. Then with the extra time which the removal of useless work will give us, our mathematical product would hold at the time when we present it to the public or to the higher institution of learning, all the original factors raised to their highest power by continued multiplication, all the zero, fractional and imaginary factors replaced by real integral ones, all signs of operations gone, and the product reduced, simplified, ready to take its place in the great world's problem.

THE ANGLE SUM OF THE GENERAL POLYGON.

By J. S. Brown,

San Marcos, Texas.

Definitions: A polygon is a broken line lying in a plane, whose end points coincide. The parts of the broken line are called the sides of the polygon. Polygons are either *simple* or *cross*. A simple polygon is one, no two of whose sides cross unless produced. A cross polygon is one, two or more of whose sides cross without being produced. Any part of a cross polygon which, taken alone, is a simple polygon is called a *segment*.

Angle sum: The angle sum of a polygon is the sum of the angles formed on one side of the perimeter of the polygon. Hence, there are two angle sums in a polygon, corresponding

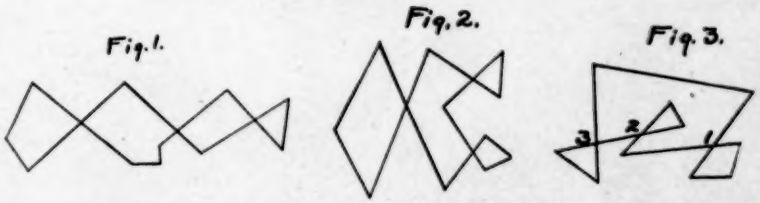
The right angle is the unit of angular measurement in this paper.

to the two sides of the perimeter. Since the value of an angle does not depend on the length of the sides of the angle, and also since the angle sum of a simple polygon depends only on the number of sides and not on the shape of the polygon, it follows that a polygon may be deformed into another polygon whose angle sum is the same, either by moving the perimeter and lengthening or shortening the sides, as may be necessary or convenient, or by keeping the sides intact or parallel with themselves, and shortening or lengthening the sides as may be necessary or convenient. (The term *deformed* hereinafter used has the above meaning.) In deforming the polygon, no angle must change sides of perimeter, i. e., from interior to exterior or *vice versa.*

Any cross polygon may be deformed so that none of the segments overlap, that is so that the various segments are either exterior or interior to each of the other segments.

Cross polygons are of two types. One is illustrated by figure 1 in which the consecutive segments have their interior angles on opposite sides of the perimeter of the cross polygon. A polygon of this type can be deformed into a simple polygon. if it has an *odd* number of segments: into a cross polygon of two segments exterior to each other, if it has an *even* number of segments. In the first case, the angle sum is by ordinary proof $2(n\pm2)$ right angles; in the second case $2n$ right angles.

The other type is one in which two or more consecutive segments have their interior angles on the same side of the perimeter of the polygon respectively. This type is the most general form of the polygon, i. e., a polygon drawn at random would likely fall in this type, and is illustrated in figure 2.



In this type there is at least one segment more than two of whose sides produced are sides of other segments. Evidently the segments of a cross polygon may be divided into two classes, one class having its interior angles on one side of the perimeter, and the other class having interior angles on the other side of the perimeter.

Problem: To find the angle sum of a polygon of the second type. Let $a+1$ be the number of segments whose interior angles are on that side of the perimeter occupied by the interior angles of a segment having more than two sides which produced are sides of other segments; or if there is no such segment then $a+1$ may be the number of segments whose interior angles are on one side of the perimeter and b be the number of segments whose interior angles are on the other side of the perimeter. Let N′, N″, etc., be the number of sides of the $a+1$ segments respectively and let N_1, N_2, etc., be the number of sides of the b segments respectively.

Now referring to Fig. 3 it is evident that in counting the angles of the polygon, the angles at the cross points 1, 2, 3 are not angles of the cross polygon. So in estimating the angle sum these angles must be counted out, since they are counted in, in estimating the angle sum of the segments separately. In estimating the angle sum on both sides of the perimeter, the whole perigon about these cross points is counted in estimating the angle sum for the segments separately.

The interior angle sum of the $a+1$ segments is: $2[N'+N''+N'''+\ldots\ldots-2(a+1)]-4a$ since there are a cross points in $a+1$ segments. The exterior angle sum of the b segments is $2(N_1+N_2+N_3\ldots\ldots)$. Adding these two expressions to get angle sum on one side of the perimeter, we have $2(N'+N''+N'''\ldots\ldots+N_1+N_2\ldots\ldots-2-2a)-4a=2(N'+N''+\ldots\ldots N_1+N_2+\ldots\ldots-4a-2)$ ..... (1)

Let N be the number of the sides of the cross polygon, then

$N=N'+N''\ldots\ldots+N_1+N_2\ldots\ldots-2(a+b)$ .. (2)

$\therefore N'+2a+2b=N'+N''+\ldots\ldots+N_1+N_2\ldots\ldots$ (3)

Substituting in (1) gives

$2(N+2a+2b-4a-2)=2(N-2)-4(a-b)$

Since 4N is evidently the angle sum on *both* sides of the perimeter and $2(N-2)-4(a-b)$ is the angle sum on *one* side. Then $4N-[2(N-2)-4(a-b)]=2(N+2)+4(a-b)$ the angle sum for the other side of the perimeter. These two may be written as one formula as follows: $2(N\pm2)\pm4(a-b)$, the double sign corresponding to the two sides of the perimeter.

AN ECOLOGICAL SURVEY OF THE DRIFTLESS AREA OF ILLINOIS AND WISCONSIN.

By H. S. Pepoon, M.D.,

Lake View High School, Chicago.

The Foreword.

A plan long cherished by the writer, to make a botanical survey of that portion of Illinois and Wisconsin known to the geologist as the *driftless area,* was put into active operation during the summer of 1908, when continuous exploration was undertaken for sixty days during the months of July and August. Much work of a more or less desultory nature had been accomplished before this year, extending over a period of nearly thirty years, or from boyhood days, and resulting in many valuable observations and the accumulation of a large amount of data, much of which is now not obtainable at any cost.

The Reasons for the Survey.

Two main reasons may be given for the survey. The first is that this area was the birthplace of the writer, and from boyhood on he had traversed the hills and valleys and was familiar with every mile of its territory, and the familiarity was due to the zeal for botanical collection that actuated the miles and miles of tramping, spring, summer, fall and winter. The second and important reason from the standpoint of ecology is that, owing to the unique geological history of the area, hinted at in the term "driftless area" commonly applied to it, there might be found many interesting and peculiar features of plant life indicative of problems in distribution that would have solutions found in the exceptional geological history of the region. Hinted at above, it has long been an accepted conclusion that for some reason or reasons not clearly understood, a large part of southwestern Wisconsin, Jo Daviess County and adjacent parts of Illinois, and that portion of Iowa immediately contiguous, were not covered by the ice sheet of the glacial period, but seemed to be an island in the midst of the otherwise universal ice.

It is not necessary for our purpose to review the facts and phenomena that are adduced to prove this peculiar history, which yet are so palpably engraven on the earth's face that the merest tyro in physiographic knowledge could see erosive and not ice sheet agency as the creative factor. Reference may be

made to works by various authors, given in the subjoined footnote,* for a full discussion of this interesting subject.

Topographic Peculiarities.

It is, however, pertinent to enlarge somewhat on the topography because it is so strikingly different from any other part of Illinois to the east and south, and to corresponding regions in the states named. The area is remarkable for the complexity and the completeness of its lines of drainage, that part occupying the center of the survey in Jo Daviess County having ten parallel streams debouching into the Mississippi River within a distance of twenty-five miles and these streams and their tributaries form a veritable network of interlocking water courses, separated by ridges of lower or higher elevation and varying in width from a few rods to several miles.

The result of all this complex system of depressions and elevations is an exceedingly rough land surface, oftentimes precipitous, with a total absence of incomplete drainage and pond and lake formations, so characteristic of glaciated regions. Only along the Mississippi River are any isolated water bodies found, and these have their origin in the floods of the great river.

The elevation above the sea varies from 1,100 feet for the general surface of the divides of the northeastern part, to 580 for the level of the Mississippi River at the southwest, or a decrease in elevation along a line of twenty-five miles running northeast and southwest of more than 500 feet. This gives for the average slope, 20 feet to the mile; on the contrary, a line running northwest and southeast, from the bluff at East Dubuque to Plum River Valley in the north part of Carroll County would have elevations at close intervals, reading as follows: Mississippi River, 600 feet; bluff at East Dubuque, 840 feet; Menominee River, 620 feet; Ridge, 860 feet; Galena R. 605 feet; Rice Township Upland, 900 feet; Small Pox Creek, 650 feet; Elizabeth Township (N. W.), 900 feet; Apple River, 720 feet; Terrapin Ridge, 1,100 feet; Little Rush Creek, 700 feet; Pleasant Ridge, 950 feet; Big Rush Creek, 700 feet; N. W. Pleasant Valley, 860 feet; Plum River, 700 feet; Ward's Grove, 1,000 feet. This line would be about 40 miles in length.

Mounds.

The northeastern part of Jo Daviess County is characterized by a series of so-called *mounds*, very notable features of the landscape, having an elevation of between 1,100 and 1,300 feet

*U. S. Geological Survey Vol. 3; Geology of Wisconsin Vol. 1.

and extending with broad intervals in a northwestern and southeastern direction from Charles Mound on the Illinois-Wisconsin line to Ward's Grove, about eighteen miles. These mounds rise at first by gentle and then by abrupt slopes from the general elevations of the surrounding regions and are capped as a rule by Niagara Limestone escarpments, which often take curious castellated forms. In size, they vary from circular forms of forty acres or less to ridges of eight or ten miles in extent, whose summits are occasionally so narrow that room is barely found for the ever present county road.

The Streams and Valleys.

Practically all the streams in their upper and middle courses are confined to narrow valleys with one or both borders precipitous to a greater or less degree, often assuming cliff formations, the limestone ledge varying from ten to 150 feet in height, and often with undermined bases, showing marked erosive action. A seeming paradox is found in this constant occurrence of cliff and gorge, for the county is presumably one of the oldest of emerged areas and ought to have valleys to correspond. The lower reaches of all the streams bear out this presumption, and the youthful aspect of all the upper valleys, particularly that of Apple River, is explained by the remarkable change that was wrought in ancient drainage channels by the damlike action of the glacial drift border, closing the former outlets and compelling an erosion of new and comparatively modern channels. This is strikingly shown in Apple River, whose pre-glacial source was in the southwestern part of Wisconsin, only twelve miles from the Mississippi River, and whose waters emptied into the Pecatonica River, a chief affluent of Rock River but which at present joins the Mississippi River after forcing a gorge-like passage ten miles or more long, into an ancient stream valley to the southwest. (See Leverett and others for a discussion of this theme.)

The Wooded Portions.

The whole area, except the glacial upland border, was originally in forest, but a large proportion of the land has been cleared and is now in pasture or cultivation. In a report made to the University of Illinois in March, 1908, the author estimated, after long and careful investigation, that in 1848, or about the beginning of active settlement, at least eighty per cent of the area was in forest land, while in 1908, a half century

later, not to exceed ten per cent was similarly covered, and much of this had been greatly depleted of its timber. This destruction of the forest growth has had a most remarkable effect upon the water supply and the amount and variety of plant life. In *Plant Life* for 1904, I have shown how on a 230 acre farm, there were in 1876, 10 springs, four living streams, 130 acres of woodland and 355 species of plants, and at the date of the paper, no springs or streams, 16 acres of woods, and 100 species of plants.

The Problem to be Investigated.

From the above resume of the topographical features, it is evident that all these peculiarities of geological history and resulting peculiarities of land surface ought to show more or less marked influence on the plant life of the various localities. It may be well to state the problems that have presented themselves, and for which solutions have been sought, passing on to detailed discussion of each. These problems stated interrogatively are:

1. What per cent of the plants of the Driftless Area are different from those of the Drift adjacent?
2. Are there peculiar or unique plants, and if so, what seems to be the source from which they came?
3. Are there characteristic northern or southern plants?
4. Is there any sudden or well marked change in the flora at the Drift border?
5. Are there any examples of isolation of species?
6. Is there any evidence of the survival of ancient forms?
7. Do the peculiarities of local topography introduce any corresponding peculiar features of habitat?
8. How does the flora compare with that of a drift area of similar latitude?
9. Has the elevation any effect?
10. What per cent of the plants are woodland or prairie, mesophytic, hydrophytic, or xerophytic?
11. What effect, if any, has the Mississippi River on the flora?
12. What families are the best represented by species?

It is not possible here to discuss at any length any of these problems or the data collected that bears on each. Some, indeed, as yet, do not admit of full answer, but it is hoped enough has been here presented to show, in part, at least, the true solu-

tion of a number of the more important. Nine hundred and thirty-six species of flowering plants and ferns have been located up to the present time, and of these only a few of the more striking examples can be cited under each head that will help to illustrate the deductions I have made.

DRIFT AND DRIFTLESS ADJACENT AREAS COMPARED.

The Drift area of Stephenson County, on the east, and of Carroll County on the south, compared with the Driftless region in Jo Daviess County, leads me to conclude that fully ten per cent of the species present in the latter county are not present at all, or found but rarely in the Drift counties. This condition may arise, in part, from the development of forest on the Driftless soil, but the presence of many species point to an inherent difference, due to other influences. Full verification of this assumption is not as yet possible; more data from the outside are needed, but all the facts thus far observed tend to confirm rather than weaken the statement. Many of the examples given could be used with equal force to illustrate other parts of the paper. Some will be so used. In fact, many of the problems are interrelated in such a manner that it is difficult to treat of any one entirely by itself.

The Canoe Birch (Betula papyrifera), so common in colder America and everywhere in warmer latitudes an evident stray from some northern center, is abundant locally and has practically no intermediate stations until the shores of Lake Michigan are reached. The Rock Elm (Ulmus racemosa) is another forest tree very local. The White Pine (Pinus strobus), and the Prostrate Yew (Taxus baccata), are common along the bluffs and are characteristic. The former found again on Rock River near Oregon, and on Lake Michigan, the latter practically confined to the county. The Wild Snowball (Viburnum opulus), the Snowberry (Symphoricarpus racemosus), the Pipsissewa (Chimaphila umbellata) are shrubby plants that are at home here. Among the herbaceous forms are several ferns, Camptosorus, or Walking Fern, Cliff Brake or Pelleas, and Cryptogramma stelleri, Zygadenus elegans, the showy Lady-slipper (Cypripedium reginae), Fringed Orchis (Blephariglottis), Rattlesnake Plantain (Peramium), Bluebell (Campanula), Rock Primrose (Primula mistassinica), Rock Saxifrage (Sullivantia), and many others; common forms scarce or absent in the Drift. The only other county in Illinois where I have found

any of the above is Cook on Lake Michigan, and this condition will again be referred to.

Peculiar, or Unique Species.

Speaking more in detail of a few forms, some of which are named above, it will be interesting to refer at the beginning to the Primrose. This plant is so notoriously a boreal species that my statement of its abundance on the cliffs of Jo Daviess County was received by some botanical friends with some credulity. Here on damp cliffs having a northern exposure, the plant is so common that the bare rock walls assume a lavender hue at the time of the blooming in late April. It is manifestly a migrant from the northeast, and seems here to have found its southwestern limit. The leaf-rosettes are formed in August and September and persist through the winter, at least the central leaves. Square yards of rock will often be a mass of foliage in late summer. Sullivantia is another cliff plant growing on the same exposures, but it is common only on those cliffs that have a strong overhang, the plant desiring not merely absence of heat, but deep shade also. The narrow twilight side gorges are its chosen home; while not peculiar to this region, it is perhaps more abundant here than at any other station in the state. The Canoe Birch, everywhere common on the bluffs, on north exposures, as before mentioned, is found so far as the writer has observed, at no other Illinois points except near Lake Michigan, and here it forms a zone around the south end, as if it were a relic of the great ice-mass that once filled the bed of the lake, encroaching everywhere on its border. The Pipsissewa and Rattlesnake Plantain reach their highest development in Canada, far to the northeast, and here are so excessively local that only one locality has been found for each, and each contains a score or so of plants.

(*To be continued.*)

NATURAL HISTORY OF THE TRIP TO THE N. E. A. MEETING AT DENVER.

By Professor Francis Ramaley,

University of Colorado.

Few people there are in these days but have read Darwin's statement that a traveler should be a naturalist, yet it is likely that the force of the statement is seldom appreciated. It is not necessary to take a "'round the world" trip or to penetrate the wilds of unknown lands in order to learn natural history in one's travels. The man or woman entirely untrained in geology or botany may gain much on a short inland journey if the natural features of the country are pointed out by one who knows them. As tourists to the historic cities of Europe read the guidebooks beforehand, so may the traveler, before a journey across prairie or plain, prepare himself by reading an account of the natural history of the region through which he intends to travel. It is with this idea in mind that the writer has ventured to present a few facts which may interest the teachers who attend the N. E. A. meeting at Denver in July, 1909.

It may be taken for granted that the reader is somewhat familiar with the northeastern United States, and west as far as Chicago. Traveling through the states of the Middle West, as Illinois, Missouri, and Iowa, the general appearance of the country is seen to resemble that of Ohio and Indiana. Most of the territory of the Middle West north of the Ohio River was covered with an ice sheet in the glacial period, and the topography which we now see is largely the result of the glaciation of that time on the preglacial topography. As is well known, the movement of glaciers was accompanied by the transport of boulders and rock masses and finer products resulting from the grinding up of the rocks by the ice motion. At the limits of the glacier there were deposited ridges and mounds forming the terminal moraines. Rounded morainic hills, rolling country, gently undulating prairie, scattered ponds, lakes and swamps—these are characteristic of a glaciated region.

West of the Missouri River an entirely different topography exists. From a little west of this river westward this territory was not glaciated during the ice age and the soil cover is therefore not of glacial origin. Westward to the Rocky Mountains

is an area which was at one time sea bottom. The surface materials of western Kansas and Nebraska and eastern Colorado were deposited over the sea bottom and later deposits largely washed in by ancient rivers bringing waters from the west. Eastern Kansas and Nebraska have a more recent covering brought perhaps by the west winds from the regions nearer the mountains. Many of the hills in western Nebraska were formed by the piling up of sand through wind action. Others are due to general leveling of wide areas through stream erosion, which has left untouched certain places which then became hills. There is no rolling prairie and no glacial drift.

The former sea floor now slopes gently upward all the way from the Missouri River to the base of the Rocky Mountains, near Denver, the average slope being about seven feet to the mile. In places along rivers the ground is cut up by the erosion of tributaries on their way to the main streams, but at distances from the larger streams true plains conditions exist. Here extreme flatness is the rule. About ten miles west of Denver the foothills and mesas—flat-topped hills—are seen, and then the glorious granite Rockies.

Vegetation along the way is in many respects different from that of the far eastern states. Through Iowa and Missouri a rather open oak forest is the rule on higher ground, while dense, mixed forests of maple, ash, elm, and walnut, occupy the bottom-lands. Intermixed with the oak forest are stretches of prairie. Here the vegetation is a close grassland covering, without trees. Trees will, however, grow if planted, and it is a question still under discussion among botanists why they are not there naturally. It has been suggested that the absence of trees is the result of frequent fires, perhaps set by Indians, but it is more likely dependent upon dryness of soil, close cover of grass, and high wind, which make it difficult for tree seedlings to get started. Beyond the Missouri River to the west there is more and more of prairie land and less of forest.

West of the hundredth meridian, which passes nearly through the center of Kansas and Nebraska, begin the "Great Plains." Here trees do not grow naturally, except along water courses, and even if planted they must be irrigated or else carefully cultivated for a number of years. The natural plant covering of the soil is made of bunch grasses, prickly pear, and Spanish bayonet, together with a great profusion of flowering herbs, which cover the ground with blossoms in the spring season.

Generally speaking, the occurrence of forests is dependent on rainfall. The mean annual precipitation of St. Louis is thirty-seven, and at St. Paul twenty-eight inches, while at Denver it is only fourteen. There is a gradual lessening of rainfall from east to west in the area between the Mississippi River and the Rocky Mountains; at about the hundredth meridian the amount is so diminished that trees are unable to live without irrigation. At Denver some of the platted additions to the city have been set out with street trees, but such trees have eked out only a miserable existence unless situated close to an irrigating ditch. If well watered all ordinary street trees make a rapid growth at Denver.

From the railway train—if the journey is made by one of the routes which takes the traveler up a river instead of across ridges—one may see cultivated fields and fenced pastures, neat farm houses, and cottonwood groves. The wild plants along the roadside are chiefly such weeds as may be seen anywhere in the Middle West, with the addition of certain of the flowering herbs of the region itself. Cottonwood trees, box elders, lance-leaf poplars, hackberries, and a few other trees grow along the streams; but by the time Colorado is reached the traveler has left behind all of the common bottom-land trees of the east, such as maples, ash, elm, butternut, walnut, and ironwood. None of these occur naturally in Colorado, yet all will grow there at moderate altitudes—4,000 to 7,000 feet—if set out and cared for.

If the traveler should choose one of the railways which extend along the higher part of the plains, there will be no trees to break the flatness of the landscape. But if the trip is made in June he will be delighted with the wonderful array of wild flowers. Farm houses are few and the half-starved inhabitants of the high plains do not trouble to fence their pastures nor plant shade trees. Once in three or four years they are able to raise a crop, but during the rest of the time they must rely upon their cattle. It is hoped by students of "dry farming" that by improved methods of tilling the soil these farms may in time be made productive, but at present they are by no means so successful as those which are near enough to rivers to permit of irrigation.

Since many of the visitors to the N. E. A. meeting will remain in Colorado for some time, a few words in regard to

the natural history of the state will not be amiss. In the first place it is well to remember that advertising matter of railroads and mining companies seldom contain scientific information of value. These tell of the great volcanic eruptions which produced the Rocky Mountains, and every cone-shaped peak is described as an ancient volcano. As a matter of fact the Rocky Mountains were formed by the folding of the earth's crust, and there are few places within a hundred miles of Denver that show trace of former volcanic activity.

The wild flowers and trees of Colorado are among the most interesting in the world. Nearly 3,000 different species of flowering plants are known in the state, a larger number than is known for any other state except California. Different altitudes are accompanied by different climates, so that a very wide diversity of plant life is permitted. It may be of service to the tourist to remember that, other things being equal, a difference of 1,000 feet in altitude in mountain districts means a difference of three degrees Fahrenheit. When the temperature is eighty degrees at Denver (altitude about 5,000 feet), we may expect it to be only sixty-eight at Tolland, on the Moffat Road, where the altitude is nearly 4,000 feet greater.

Trees in Colorado are of many kinds, especially in the mountain regions, nearly all of them different from the trees of the East and of the Middle West. At high altitudes only trees of the pine family are to be found, but in the foothills there are willows, birches, alders, poplars, thornapples, and others along the water courses. Anyone interested in plants will do well to secure in Denver a book dealing with Colorado wild flowers and trees. Even a few days of travel within the state with such a book at hand will be enough to let the reader into many of Nature's secrets.

On account of the great diversity of climate and altitude, with the consequent diversity of flora, many people have become interested in Colorado plants. It is only in recent years, however, that any great amount of serious study has been put upon them by botanists. Recently the State Agricultural College at Fort Collins has published a list of all flowering plants known to occur in the state, while the professors at the State University at Boulder have printed a number of articles describing the plants of particular regions. During the present summer the State University is maintaining at Tolland (8,889 ft.)

a laboratory for the study of high-altitude plants. This is conducted as a part of the University Summer School, with classes for beginners and for advanced students.

Very few wild four-footed animals will be seen by the visitor to Colorado. In crossing the plains if one keeps a sharp lookout for prairie-dog "towns" it is possible to see a number of the prairie dogs, really squirrel-like animals, sitting bolt upright at the mouths of their burrows. At a distance, skulking along, one may catch sight of a lone coyote which has thus far escaped the bullets of cowboys and sheep herders. In the mountains there are plenty of chipmunks and an occasional squirrel, and there are still some larger wild animals. But these last are seldom seen by the tourist who comes in summer. At that season the animals are far away in the lonely parts of the subalpine forest. Only a few summer visitors are able to report views of mountain sheep, deer, and antelope, except as they may be seen in the zoölogical gardens at Denver.

But if the larger wild animals are no longer in evidence, there are plenty of birds. Nearly four hundred different species have been reported from the state, and no less than two hundred and fifty are known to nest and breed there. Only two other states, Texas and California, have so many species. In eastern Colorado one may see many common birds of the Mississippi valley which do not extend west so far as the foothill towns of Colorado Springs and Boulder. The blue jay and common crow furnish examples of this limited distribution within the state. Likewise, in the mountain districts, there are birds which do not pass down to the plains; the ptarmigan occurs only in the alpine heights, and Clarke's crow but little lower. In western Colorado, too, beyond the Continental Divide, there are birds which do not cross over to the eastern slope.

A peculiarity of Colorado bird life which interests eastern visitors is the presence of numerous "western forms." Thus the robin, the meadowlark, and the evening grosbeak which one sees in Colorado are not the same as those farther east. In these and other species there are slight but characteristic differences which separate the Colorado birds from their eastern relatives. Perhaps the dryness of the climate is, in a measure, responsible for the existence of these "western forms."

GENERAL BIOLOGY FOR THE HIGH SCHOOL.

By H. D. Densmore,

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The appearance of several text-books in general biology for high schools naturally raises the question of the advisability of adopting such a course instead of longer separate courses in botany and zoölogy. Several important considerations of a general nature seem at first sight to justify the introduction of a unit course in general biology into the high school curriculum.

Among these the time factor is an important consideration on account of the crowded condition of the high school courses. Four sciences are already represented in the regular high school curriculum and each science demands a unit of time for its adequate development. If botany and zoölogy are given separately as year courses this would require five units of time for chemistry, physics, physiography, botany and zoölogy. We are often told that this is a greater allowance of time than can be granted to the sciences in the present scheme of secondary education There is also great need for unification in the courses and in the methods of presentation in the biological sciences in our high schools. The present unsatisfactory conditions are too well known to need more than a brief review. In many high schools a half year of botany and a half year of text-book work in human physiology represent the biological sciences. If botany is given for a year, zoölogy is very rarely offered except in the largest and best high schools. Definite laboratory periods are frequently not provided for and laboratories are usually poorly equipped for good work. Such conditions should lead to a careful consideration of any plan which would tend to lessen the present unsatisfactory status of biological courses and biological teaching. There is little question that a general biology course would simplify the solution of some of the above difficulties. It would place biology on an equal footing with physics and chemistry as a unit course in science and would thus render easier the establishment of a four unit course in general science in the high schools. The general biology course would also tend to unify the plan for teaching biological science and would doubtless lead to a more general acceptance of biology as a necessary unit in the high school curriculum.

The introduction of such a course does not seem so advisable, however, when the nature and content of the course are considered. A course in general biology is supposed to be based upon biological principles and laws of a general nature to which the studies of facts and phenomena are subsidiary. It seems doubtful whether a course of this general character is adapted to pupils in the second year of the high school course. Such pupils need to study the life histories and the adaptations of the common forms of animals and plants. The facts and phenomena of such studies must be correlated by the discussion of processes and biological laws, and yet phenomena studies will naturally form a dominant element in any elementary course for high school pupils.

College teachers of general biology are well aware of this fact and always experience difficulty in presenting the general theories of biology to freshmen and sophomores. The difficulty would certainly be much greater if the attempt were made to present such a course to young pupils in a high school. The text-books which have thus far been written in general biology for high schools indicate the inherent difficulties of adopting such a course to our high school conditions. These texts are essentially short courses in botany and zoölogy and are not unified by any such general principles of biology as form the basis for the best college texts written by Parker and by Sedgwick and Wilson. It is conceivable that an interesting and profitable unit course could be planned using physiology as the central theme of the plant and animal phases of the course. A selection of experiments from such a book as Osterhout's "Experiments with Plants" supplemented by enough morphology to make the physiology intelligible would make a profitable half year in botany. Doubtless a similar course could be planned by a zoölogist to complete the year's work in plant and animal physiology. Such a course would have the inherent fault, however, of giving a much narrower point of view than the standard unit courses in botany and zoölogy which are being introduced into our best high schools. In these latter courses the time is sufficient for dealing with all of the important aspects of plant and animal life which are likely to be useful to the average high school graduate. They aim to give an acquaintance with the habits and life histories of animals and plants with which the lives of men and women are commonly associated. In addition

they allow of enough discussion and experiment concerning general principles and laws to unify and explain the phenomena studies of the course.

Such broad general courses cannot be secured unless a unit of time is allowed for both botany and zoölogy. There can be no question concerning their better adaptability and greater usefulness to high school graduates as compared with the shorter courses which would necessarily form the so-called general biology courses. These better courses are doubtless impossible in small and poorly equipped high schools. In such schools either well planned half year courses in botany and zoölogy or a choice of a year course in one of these sciences will doubtless be necessary. This fact should not deter us from planning and introducing the longer and better adapted unit courses in botany and zoölogy into the good high schools. If this latter plan is generally adopted it would seem advisable to the writer to incorporate human physiology with the zoölogy course. This would then require only one half unit of biological science in addition to the year course in botany and the half year in physiology which are now given in many high schools.

Botany and zoölogy teachers may be pardoned for the feeling that two units in biological science are not too much to offer in a curriculum in which four units are devoted to English and six to foreign languages. The opportunity is needed, especially for the boys of our high schools, to learn the principles of modern science which are dominant in our civilization to-day If boys are to be attracted to and held in our high schools the elaboration of the sciences in the high school curriculum is a desideratum.

My conclusions may be summarized as follows: A real course in general biology based upon biological principles and laws is not adapted to pupils of high school ages. The courses usually denominated general biology courses for high schools are only short courses in botany and zoölogy in which the selection and arrangement of material does not often appeal to teachers of these subjects. The longer courses in botany and zoölogy are better adapted to pupils of high school age, because they are more general, they give a broader outlook and allow of time for training in important principles and laws of biology which must of necessity be omitted in the shorter courses.

WHAT SHALL WE TEACH CONCERNING THE PHYSIOLOGICAL EFFECTS OF ALCOHOL?

By Harry Clifford Doane.

Editorial Note: This article will serve to remind us that a few years ago there was an abundance of evidence relative to the physiological effects of alcohol. But few people cared to consider it dispassionately then, owing to the obviously untrustworthy claims made by the chief exploiters of the evidence. Now, however, we may return with equanimity to the consideration of experimental data from all sources and ultimately hope to come at the whole truth.

The teaching of physiology and hygiene is far from being in a satisfactory condition in our schools. The agitation so vigorously prosecuted by some against the various state laws requiring the teaching of the effects of alcohol and narcotics and the criticisms of the accuracy of the statements on this subject found in our school physiologies seem to be in a measure responsible for a serious neglect of physiology teaching in many schools. There appears to have grown up a widespread feeling that physiology is an unfit subject for grade schools, and even for high schools unless it can be pursued in a thoroughly scientific manner by laboratory methods.

I do not wish to be understood as minimizing in any degree the value or need of making scientific subjects the means of teaching scientific methods of thought, nor would I decry the place of the laboratory in such instruction; but physiology occupies a peculiar position among the sciences as a subject of school study. It is essential to the physical welfare of the individual and of the community that the pupils of our schools acquire a knowledge of the more important principles of hygiene. These principles of hygiene are dependent for their truth on the facts of physiology, and cannot be successfully taught without some reference to physiology as a basis. The value of a knowledge of physiology and hygiene for their own sake makes it important that they be taught definitely and systematically in all schools, even though laboratory methods cannot be used, beginning as low in the grades as possible. Many facts of physiology and hygiene can be successfully taught in the first and second grades.

The claim that place should be given in our teaching of physiology and hygiene to the effects of alcohol and narcotics needs no defense. In the year ending June 30, 1907, the people of the United States consumed 2,019,690,911 gallons of distilled spirits, wines and malt liquors, according to the "Statistical Abstract of the United States," published by the government. A careful estimate gives the retail cost of this liquor as $2,275,070,857. The per capita consumption was as follows:

Distilled liquors	1.63 gallons
Wines	0.67 "
Malt liquors	21.23 "
Total per capita	23.53 "

This gives a per capita cost of $26.50.

The people can be brought to get rid of this enormous, worse than useless, expense only by educating them as to the true facts in the case.

We who are not specialists in this subject must accept and teach the conclusions of those who have scientifically and experimentally investigated the effects of alcohol upon the human body and its processes. In the following paragraphs I have collected some of the testimony of such investigation.

Effect of Alcohol on Muscular Effort.—Professor Destree of Belgium measured the weight he could lift by flexing the middle finger. In six tests he could lift nearly seventeen pounds. After fatigue came on he could lift only nine pounds in the same number of tests. When he had taken some wine and rested thirty minutes, he could raise but three and one half pounds. During a period of ten years Professor Kraepelin performed some 3,000 experiments on the effects of alcohol. He found by means of a dynamometer that the pull that could be given with the hand was weakened by taking small quantities of alcohol.

Mountain climbers usually recommend that no alcoholic drinks be used just before or during the climb. Professor A. Durig reports the results of experiments performed in 1906 to determine the effect of alcohol on mountain climbing. Careful observation of the subject of the experiment in climbs when "2 to 2.5 fluid ounces of alcohol, equivalent to about a pint of wine, were taken before the ascent" and also when no alcohol was taken, showed that "alcohol diminished the amount of work performed per minute by about one-sixth."

In "Physiological Aspects of the Liquor Problem," Professor Hodge of Clark University describes many of his own experiments showing the effect of alcohol on animals. He trained four selected puppies to recover a ball thrown across a gymnasium. To two of the dogs he gave food mixed with dietetic doses of alcohol while the others were fed normally. The ball was thrown 100 feet as rapidly as recovered. This was repeated 100 times each day for fourteen successive days. Out of the 1,400 times the dogs to which alcohol had been given brought back the ball only 478 times, while the others secured it 922 times.

Dr. Parkes experimented with two gangs of men, selected to be as nearly similar as possible, in mowing. He found that with one gang abstaining from alcoholic drinks and the other not, the abstaining gang could accomplish more. On transposing the gangs the same results were repeatedly obtained. Similar results were obtained by Professor Aschaffenburg of Heidelburg University, who found experimentally that men "were able to do 15 per cent less work after taking alcohol." Professor Abel of Johns Hopkins University says: "Both science and the experience of life have exploded the pernicious theory that alcohol gives any persistent increase of muscular power."

Alcohol and the Circulation.—As a result of experiments performed in 1869, Zimmerberg declares: "In the light of these experiments one is not only justified in denying to alcohol any stimulating power whatever for the heart, but, on the contrary, in declaring that it lowers the working capacity of that organ."

Dr. J. H. Kellogg, head of the Battle Creek Sanitarium, says: "The full bounding pulse usually produced by the administration of an ounce or two of brandy properly diluted, gives the impression of an increased vigor of heart action; but it is only necessary to determine the blood pressure by means of a Riva-Rocci instrument, or Gaertner's tonometer, to discover that the blood pressure is lowered instead of raised. This lowering may amount to twenty or thirty millimeters, or even more. * * * It can readily be seen, then, that the bounding pulse is not the result of increased heart vigor, but indicates rather a weakened state of the heart, combined with a dilated condition of the small vessels."

In an address before the Liverpool Medical Association, Dr. James Barr, president of the association, discussing the effects

of medicinal doses of alcohol upon the circulation remarked: "It causes dilatation of the arterioles and of all arteries well suppied with muscular fibers, owing to its paretic effect upon the vasomotor nervous system, and its direct action as a protoplasmic poison on the muscular fiber. It has a similar, though less marked, action on the cardiac muscle. From these causes the systolic blood pressure is lowered, the systolic output from the heart is diminished, and the cardiac energy is wasted in pumping blood into relaxed vessels; the large bounding pulse with comparatively short systolic period, which gives a deceptive appearance of vigor and force in the circulation, is due to the large wave in the dilated vessels."

Effects of Alcohol on the Nervous System.—In an article in the *Journal of Inebriety,* Dr. J. W. Grosvener of Buffalo says: "Alcohol is a paralyzer. The truth of this proposition has been demonstrated experimentally scores of times by world-famed physiologists. Says Forel: 'Through all parts of nervous activity from the innervation of the muscles and the simplest sensation of the highest activity of the soul the paralyzing effect of alcohol can be demonstrated.' Several experimenters of undoubted ability have noted the paralyzing effect of alcohol even in small doses. By the use of delicate instruments of precision, Ridge tested the effect of alcohol on the senses of smell, vision, and muscular sense of weight. He found that two drams of absolute alcohol produced a positive decrease in the sensitiveness of the nerves of feeling, that so small a quantity as one half dram of absolute alcohol diminished the power of vision and the muscular sense of weight. Kraepelin and Kurz by experiment determined that the acuteness of the special senses of sight, hearing, touch, taste, and smell was diminished by an ounce of alcohol, the power of vision being lost to one third of its extent and a similar effect being produced on the other special senses. Other investigators, as Crothers, Madden, Kellogg, Frey, von Bunge have reached like conclusions."

Dr. Kellogg, previously quoted, in an article giving conclusions from experiments by himself and others says: "Kleefeld has shown that alcohol, when taken into the blood, produces almost immediately a marked change in the minute structures of the brain. The dendrons and contact globules are shriveled, thus breaking contact and thus interrupting the normal nerve circuits. This fact explains, to a large degree, the mental and

moral effects of alcohol, especially its effect in destroying inhibition. When often repeated, this toxic effect gives rise to degenerative changes which are seen in their full development in general paresis. The flushing of the face seen after the administration of alcohol, and the exhilaration felt by a person in ordinary health, are due, not to a stimulating effect, but rather to a paralyzing or sedative effect. * * * A person who is fatigued, after taking alcohol feels relieved, not because he is rested or because his muscles have been reinforced, but because the nerves of fatigue are paralyzed so that he no longer appreciates the fact that he is fatigued. A person who is cold, after taking a dram, no longer suffers from cold or chilliness, and imagines that the alcohol has warmed him. This is not the case, however. The alcohol has only lessened the sensibility of his thermic nerves, so that he is less sensitive to cold, while at the same time increasing the flow of blood to the skin by paralyzing the vasomotor centers."

With regard to the supposed quickening of the mental processes Horsley and Sturge, in their recent book, "Alcohol and the Human Body," say: "Kraepelin found that the simple reaction period, by which is meant the time occupied in making a mere response to a signal, as, for instance, to the sudden appearance of a flag, was, after the ingestion of a small quantity of alcohol (¼ to ½ ounce), slightly accelerated; that there was, in fact, a slight shortening of the time, as though the brain were enabled to operate more quickly than before. But he found that after a few minutes, in most cases, a slowing of mental action began, becoming more and more marked, and enduring as long as the alcohol was in active operation in the body, i. e., four to five hours. * * * Kraepelin found that it was only more or less automatic work, such as reading aloud, which was quickened by alcohol, though even this was rendered less trustworthy and accurate." Again: "Kraepelin had always shared the popular belief that a small quantity of alcohol (one to two teaspoonfuls) had an accelerating effect on the activity of his mind, enabling him to perform test operations, as the adding and subtracting and learning of figures more quickly. But when he came to measure with his instruments the exact period and time occupied, he found, to his astonishment, that he had accomplished these mental operations not more, but less, quickly than before. * * * Numerous further experiments were

carried out in order to test this matter, and these proved that *alcohol lengthens the time taken to perform complex mental processes,* while by a singular illusion the person experimented upon imagines that his psychical actions are rendered more rapid."

Relation of Digestion and Nutrition to Alcohol.—As a result of his own experiments Prof. Chittenden of Yale University remarks: "We believe that the results obtained justify the conclusion that gastric digestion as a whole is not materially modified by the introduction of alcoholic fluids with the food. In other words, the unquestionable acceleration of gastric secretion which follows the ingestion of alcoholic beverages is, as a rule, counterbalanced by the inhibitory effect of the alcoholic fluids upon the chemical process of gastric digestion, with perhaps at times a tendency towards preponderance of inhibitory action." Kellogg, Sir William Roberts and others have come to the same or stronger conclusions as to the undesirable action of alcohol on digestion, as a result of their own experiments.

Horsley and Sturge, in their book previously mentioned, say: "Hundreds of men and women who haunt the out-patient departments of hospitals suffer from chronic atony and slight dilatation of the stomach, which arise in part from the badly cooked food they eat, but chiefly owe their origin to the debilitating effect of alcohol upon the muscular walls of this organ and the fermentation of its retained contents."

The experiments of Professor Atwater demonstrated that a certain amount of alcohol is oxidized in the body. As the oxidation produces energy he held that alcohol was a food. To call alcohol a food is to distort the meaning of food as ordinarily used and few of the physiologists who can properly be considered authorities agree with Atwater in calling alcohol a food instead of a poison.

Kellogg points out that strychnine, quinine and many other drugs are oxidized in the body, but surely cannot be called foods. The following reasons for not considering alcohol a food are taken from Kellogg:

"1. A habitual user of alcohol has an intense craving for his accustomed dram. Without it he is entirely unfitted for business. One never experiences such an insane craving for bread, potatoes, or any other particular article of food. * * *

"2. By continuous use the body acquires a tolerance for al-

cohol. That is, the amount which may be imbibed and the amount required to produce the characteristic effects first experienced gradually increase until very great quantities are sometimes required to satisfy the craving which its habitual use often produces. This is never the case with true foods. * * * Alcohol behaves in this regard just as does opium or any other drug. It has no resemblance to a food.

"3. When alcohol is withdrawn from a person who has been accustomed to its daily use, most distressing effects are experienced. * * * Who ever saw a man's hand trembling or his nervous system unstrung because he could not get a potato or a piece of cornbread for breakfast? In this respect, also, alcohol behaves like opium, cocaine, or any other enslaving drug.

"4. Alcohol lessens the appreciation and the value of brain and nerve activity, while food reinforces nervous and mental energy.

"5. Alcohol as a protoplasmic poison lessens muscular power, whereas food increases energy and endurance.

"6. Alcohol lessens the power to endure cold. This is true to such a marked degree that its use by persons accompanying Arctic expeditions is absolutely prohibited. Food, on the other hand, increases ability to endure cold. The temperature after taking food is raised. After taking alcohol the temperature, as shown by the thermometer, is lowered.

"7. Alcohol cannot be stored in the body for future use, whereas all food substances can be so stored.

"8. Food burns slowly in the body, as it is required to satisfy the body's needs. Alcohol is readily oxidized and eliminated, the same as any other oxidizable drug."

The superintendent of the Northern Illinois Hospital for the Insane, Dr. Vaclav H. Podstata, says: "Alcohol is unquestionably a direct and powerful poison to the nervous structure. It not only temporarily impairs and prevents the activity of nervous tissue, but in a measure, though at times very minute and almost imperceptible, every dose of it permanently disables the functional activity of those organs."

(*To be continued.*)

THE TIME INTERVAL BETWEEN THE TIDES.

By Herbert C. Wood,

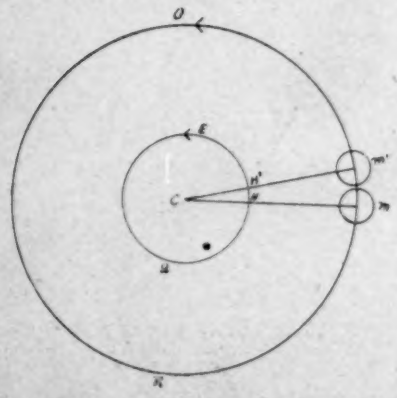
East High School, Cleveland, O.

I have found the following calculation of the time interval between the tides to be an excellent exercise for high school pupils in their second year. It can also be comprehended by first-year pupils, after they have learned to handle equations involving one unknown quantity.

It makes a good blackboard demonstration, and the diagram may be used to explain spring and neap tides, if another circle be drawn at the right to represent the sun. Circles to represent the moon at various times of the lunar month may also be added as required. It is a good idea to begin the subject of the tides with a very simple diagram and then to add to this such features as are necessary to illustrate the different phases of it, rather than to employ several separate diagrams. This will preserve the continuity of thought and enable the pupils to grasp the problem of the tides as a concrete whole.

The diagram presented is made as simple as possible for the purposes of the problem of the time interval.

Teachers of mathematics will recognize the traditional "hare and hound" problem, but perhaps this one will appeal to the students as more "worth while."



Let the circle OR represent the moon's orbit and the circle EQ the earth's equator, which are concentric about the earth's center, C, the observer being above the earth's north pole.

Let the small circle, m, represent the moon at any convenient hour, say 9:00 h. A. M. of a given day, and H the place where the tide is high at that time.

Let m' represent the moon when the tide is high at about the same time the next day, the eastward direction of the moon's revolution and of the earth's rotation being indicated by arrows, and the angle mcm' being made about 13°.

The problem, then, is to find the time required for H to make one complete rotation and enough more to bring it into line with m′ and C, i. e., to H′.

Let x=the arc mm′(=arc HH′)=the angular distance the moon travels.

Then 360+x=the total angular distance H travels.

Since the earth rotates through 15° per hour $\left(=\frac{360}{24}\right)$, then $\frac{360+x}{15}$ = total time H travels.

Since the moon travels .535° per hour $\left(=\frac{360}{28\times 24}\right)$, then $\frac{x}{.535}$ = total time the moon travels.

Therefore since the two times are equal $\frac{360+x}{15}=\frac{x}{.535}$, whence x = 13.3 and $\frac{360+13.3}{15}$ = 24 h. 53.3 m., and the tide would be high at 9 h. 53.3 m. A. M., the next day.

The time between two *successive* high tides may be obtained from the equation

$\frac{180+x}{15}=\frac{x}{.535}$, whence x=6.6 and $\frac{180+6.6}{15}$ = 12 h. 26.4 m. and the next high tide will occur at 9 h. 26.4 m. P. M. the same day.

The time between the first high tide and the low tide next following may be obtained from the equation

$\frac{90+x}{15}=\frac{x}{.535}$, whence x=3.3 and $\frac{90+3.3}{15}$ 6 h. 13.2 m., and the low tide will occur at 3 h. 13.2 m. P. M. the same day.

PRACTICAL EXERCISES IN PHYSICAL GEOGRAPHY WITH ATLAS. By William Morris Davis, *Ginn & Co., 1908.*

Those who attended the meetings of the Earth Science section of the Central Association of Science and Mathematics Teachers in Chicago, two years ago, will recall the illustrated lecture by Professor Wm. M. Davis on laboratory exercises in physical geography, and the promise that a book of these exercises would soon be published. The "Practical Exercises in Physical Geography," and the accompanying "Atlas" is a fulfillment of this promise. The text consists of 144 pages of questions and directions, of which 114 pages are on land forms, and the others on temperature distribution, winds, weather maps, and ocean currents. In the "Atlas" there are forty-five pages of plates con-

sisting of about 200 figures. About eight-ninths of these figures are devoted to land forms. Among the plates there is a map of each of the continents, except Australia, like those which have been found so useful in Professor Davis' text-books on physical geography. There are five pages (19 figures) of topographic maps printed in three colors, similar to the contour maps of the U. S. Geological Survey, but made somewhat simpler and easier for the beginner to read. By far the greater number of figures, however, consist of block diagrams, accompanied by maps and sections, illustrating the successive stages in the history of plains, plateaus, and mountains, and the development of rivers, valleys, and shore lines. It was one of the great advantages of the earlier text-book of Professor Davis on physical geography, that the block diagrams could be made the basis of exercises in interpretation of the landscape. When the Davis "Elementary Physical Geography" came out with its improved treatment of the atmosphere, better adapting it to the use of first-year high school students, and its additional chapter on the distribution of organic forms (the best short treatment in the English language) there was a feeling of regret that a few of the block diagrams that were in the earlier work had been omitted. Whatever regret may have arisen on this account in the minds of those who recognized the opportunities the block diagrams gave for exercises in interpretation will be wholly dissipated by the wealth of illustrations which may be so used in the "Atlas for Practical Exercises in Physical Geography." Teachers will not be slow in recognizing the skill with which the questions in the "Exercises" are directed so as to force upon the attention of the student the important points brought out by the illustrations. It is no small advantage of the exercises that they not only train the eye to see and the mind to interpret, but also that by the simple exercises in drawing they concentrate the attention of the student upon the important points and at the same time give the young student an opportunity to gratify his desire to do something with his hands. It is not intended that the study of these plates shall take the place of study in the field. It must be seen, however, that where field lessons are impossible, these exercises will be used as a substitute. Whether used with field work, or without, they will be a great advantage. They should be welcomed by every English-speaking teacher of the subject, whether in America or elsewhere.

For students who have studied physics and have had some elementary work in astronomy, the thirty pages of exercises given to a study of the atmosphere and the oceans will be satisfactory. For those who have not had such preparation these exercises should, in the opinion of the reviewer, be supplemented by exercises and experiments which shall supply these essentials. In some cases, notably plate thirty-three, figure two, the exercises crowd so much onto one figure that it is confusing to the young student. It would have been better if the publishers had made the "Atlas" a loose leaf book, for the first attempts often spoil a plate and it should be made possible to replace any of them easily.

Students of the science of physiography have been greatly indebted to Professor Davis in the past for contributions to its progress, a debt which has been recognized in the dedication of a recent book of travel to him as "the first of modern geographers." Students of the teaching of the subject have been indebted to him in the past, and are now put under greater obligation by this contribution. The teaching of physical geography will be lifted to a higher plane by it. It is to be hoped that the author's anticipations may be realized and that "the careful performance of the exercises will lead the pupil to observe, to describe, and to generalize; to make inferences, to invent explanations, and to test theories; to express new ideas verbally and graphically. If the teacher is patient and does not infringe too often on the pupil's right of discovery, the pupil may make so much progress in these various processes, and at the same time acquire so good a knowledge of a great group of natural phenomena, that he will really be led to make a beginning in the formation of scientific habits of thought."

THE CORRELATION OF HIGH SCHOOL AND COLLEGE PHYSICS.*

By Robert A. Millikan.

The University of Chicago.

During the past twenty years, through college entrance examinations, college entrance requirements, and syllabi originating largely with college men, the colleges have as a whole exercised a large influence, perhaps we might even say a control, over the character of the course in physics given in the secondary schools. I do not intend to attempt to balance the good and evil which has resulted from this situation. Suffice it to say that there is doubtless a tendency to underestimate the good and overestimate the evil, since it is easy to attribute everything which is bad in present conditions to this influence, while it is equally easy to be oblivious of the good. Indeed, we should be in position to correctly estimate the good only if we could know what sort of physics would have been taught to-day in our high schools if college influences had been absent.

The problem which is assigned to me this afternoon is that of attempting to point out how college and high school physics may be made to fit together better than they do to-day. I cannot well do this without defining in some way the field of each. I confess this is a task which I am loath to undertake, for, unless I can take the time to go over with you in minute detail outlines of both courses—a procedure which time obviously forbids—I am in very grave danger of precipitating one of those profitless discussions which arise from misunderstandings. Indeed, it seems well-nigh impossible to avoid discussions of this sort so long as we speak *in general terms* of the aims and methods of physics. It is only when we discuss the *details* of our courses that we discover just what our fundamental differences really are, and, I may add also, how small they are. I am aware that here and there one may feel that to minimize these differences is to cry, "Peace, peace, when there is no peace;" and yet, despite the floods of extravagant denunciation of all physics which occasionally break loose in our journals, it is a most remarkable fact that, in general, when the denouncer makes his denunciation concrete (which is far too seldom the case) he de-

*An address delivered in Chicago before the physics section of the Central Association of Science and Mathematics Teachers November 27, 1908.

nounces something of which practically nobody is guilty, and when, on the positive side, he gives *concrete illustrations* of what he means by "vitalizing physics" he brings forward some of the pet illustrations of nine tenths of the rest of us physics teachers. I have recently seen a list of illustrations of this sort fully three fourths of which are found in practically all of the standard elementary texts. Again it is a notable fact that the most striking characteristic of the various outlines of units which have been put forward by the several parties in our physics discussions—by the "terrible reds" on the one hand, who hold, in print at least, that conditions are so bad that there is nothing to do but blow them up and start over, by the "constitutional democrats" who want moderate reform, by the Octoberists, or stand-patters, and by the ultra-reactionaries, is their remarkable similarity. The fact is that when we consider the actual detailed outline of a first course in physics, and turn our eyes away from the horrible straw men whom we conjure up to represent the opposition, while we grow warm and eloquent over general principles, there isn't a very large range of topics about which experienced and thoughtful teachers can seriously disagree. Finding the real issue in many a heated discussion in physics conferences is quite as difficult as finding the real difference between a Republican and a Democrat. I know, of course, that we have our party shibboleths, but half of them at least are nothing but shibboleths, that is, they are *words rather than ideas.* One man, for example, says that he wants physics to be *essentially quantitative,* and straightway, before he has had time to define what he means by quantitative, another interjects the vehement assertion that he doesn't want it to be quantitative, that he wants it to be a study of *the hows and whys of the phenomena of daily observation,* and at once the fight is on. Now, if the declaration of war could only have been delayed long enough to make it possible to ask the first man if he meant that he wished to omit teaching the hows and the whys of the phenomena of daily life, he would have said, "Certainly not. Every respectable teacher always does, and always has done that anyway, but my opponent over there is attacking the idea of quantitative work and that attack is pernicious." If then we can ask No. 2 if he wishes to omit all quantitative work he will reply in every case, "Certainly not; but I don't believe in my opponent's kind of quantitative work." Now if we can only persuade

these two men to compare each other's courses in a friendly way we usually find that they differ by perhaps four or five experiments in forty.

Barring then the occasional extremist, who doubtless deludes himself into imagining that he represents general opinion, I am ready to assert with considerable positiveness that our fundamental differences are very much smaller than many of us imagine, and that if we would come together in a spirit of harmony rather than of strife it is a relatively easy matter for any body of able and experienced physics teachers to agree upon the essential elements of a first course.

Turning next to the topic of the afternoon, if we are to effect a cure for existing evils we must know how they have arisen. When then we seek to know the reason that the colleges have exercised so large an influence upon secondary school work, we find that it has been rather the result of a situation for which the colleges have not been responsible than because of a deliberate attempt on the part of college men to dictate to the secondary schools. And let me say in this connection that nothing could possibly be farther from the truth than the idea that to-day college and high school men are arranged in antagonistic camps over the question of the character of a high school course in physics. If college men are well nigh unanimous in opposing certain particular types of suggested changes it is only because these changes are of such a character that experienced and thoughtful teachers, whether in colleges or in high school, regard them as subversive of the foundation principles of sound education. College men are not only ready and anxious to cooperate in every possible way in effecting real improvements in high school physics, but they are as a whole ready to turn over entirely to the high school teachers of the country the complete determination of the high school unit in physics. I have been repeatedly assured of such willingness by some of the most conservative college physicists in the country. The only reason that it has not been done in the past is that *the secondary school physics teachers have not been so organized as to make it possible to obtain representative opinion from them.* There has never been prepared in the history of this country a syllabus, or outline of a secondary school unit in physics, which originated in such a way as to make it possible to assert with any sort of confidence that it represented the consensus of opinion

of the competent secondary school physics teachers of the country as to what the high school course in physics should contain. The fact that the colleges have exercised during the past twenty years a predominating influence upon the character of the high school course has arisen simply because colleges must, in the nature of the case, have some kind of standards of admission, and since the high schools have had absolutely no uniform standards of graduation, in other words, since units have not been defined by secondary school men, the colleges have been obliged to define them whether they wanted to or not.

College men recognize just as fully as high school men the evils which have resulted from this situation. They recognize that college entrance examinations and the fixing of college entrance requirements have often been put into the hands of men who were little conversant with secondary school conditions. They recognize that college standards have thus often been forced down into the high school where they have no place. They recognize too that there has been little uniformity among the colleges in the matter of their entrance requirements, and that high school courses have sometimes almost been torn to shreds by the frantic efforts of teachers to meet the entrance requirements of all sorts of schools. And it has been because college men *have* recognized these conditions that organizations like the College Entrance Examination Board and the North Central Association have been formed with a view to remedying these very evils. And I am glad to be able to say that the worst of the evils have already been remedied, at least, in the middle West. Certain it is that in a city like Chicago, or in almost any other city in the territory of the North Central Association, the high school teachers of physics do not feel the pressure of college entrance requirements. They have practically a free hand to teach physics according to the dictates of their own consciences, their own intellects, and their own experience. If they are teaching a dead physics instead of a living one (a supposition I think quite contrary to fact), it is because they do not know how to teach a live physics, and not because the colleges are forcing them to continue teaching a dead physics.

And yet taking the country as a whole it is undoubtedly true that some evils which have resulted from college domination still remain to be eliminated, and certainly there is still a great deal to do in the way of *unifying* the teaching of high school

physics. But if I analyze the situation correctly the colleges have gone about as far in the way of remedying these evils as it is possible for them to go so long as they are constituted and organized as at present. *The remedy, and in my judgment the only remedy for the evils which remain is to be found in the setting up of a representative unit in physics by the secondary school physics teachers of the country.* There cannot be a particle of question that if such a unit could be set up in a way which would make it practically certain that it represented the consensus of opinion of the most competent secondary school teachers in the whole country, the colleges from Maine to California would, without exception, accept that unit in satisfaction of their entrance requirements. In so far, then, as the secondary schools are still oppressed by college entrance requirements the sole remedy for the situation is for them to get together and set up their own norm. A national convention of say fifty representative secondary school teachers of physics would cost some money, but that is after all not an insuperable obstacle. After such an assembly had once been convened I should anticipate that it would have little difficulty in agreeing upon an outline of a unit.

This then is the part which the secondary schools must take in the correlation of high school and college physics. The remainder of the problem is the problem of the colleges. Their first step should be, and doubtless would be to accept the norm established by the secondary schools in satisfaction of their entrance requirements. Their second step in my judgment should be, and I certainly hope that it would be, to do away with all college courses which are neither first courses nor second courses but crosses between them designed to strike some sort of a mean between the needs of the students who have had no preceding work in physics and those who have had a full year of such work. Such courses may have been necessary in the past in some institutions, in view of the very irregular preparation in physics of entering students, but, in my judgment, all excuse for them disappears as soon as secondary school physics becomes fairly well unified. Certainly the mixing in the same class of students who have had no preceding work in physics with those who have had a full year of such work is wholly unsound pedagogically, and furthermore it furnishes one of the most just grounds of complaint on the part of the high schools against

the colleges, for it amounts to discrediting completely the high school course. There is precisely the same need of continuity and progression in the study of physics as in the study of mathematics or of language. A first year course should obviously be of a wholly different character from a second year course unless we make the astonishing admission that we teach nothing in beginners' courses. The assertion sometimes credited to college physicists that it is a matter of entire indifference to them whether their pupils have had preceding work in physics or not is one which it is difficult to believe that any thoughtful man has ever uttered. It amounts to expressing indifference as to whether a part of one's pupils waste a year of valuable time or not. If actual conditions involve such a waste it is high time that such conditions were changed.

In my judgment there are just two ways of obtaining effective instruction in physics in the college and at the same time of being fair to all classes of students. These are (1) to exclude entirely from work in physics in college all students who have not had a good high school course, and then to build up the college course in full recognition of the high school course and as a continuation of it, or (2) to do as is done now in the University of Chicago, Harvard, and I think a considerable number of other prominent institutions; namely, to offer in college two courses, one a beginner's course, covering essentially the ground of high school physics, and one, an advanced course to which students gain entrance either through taking in college the beginner's course or through offering for entrance a satisfactory high school course. During the last ten years the first plan; namely, that of making physics a prescribed subject for admission, and offering in college only an advanced course, has been abandoned by most of the prominent universities of the country; because, no doubt, of a growing recognition of the principle that the function of the American college or university is not to dictate what the secondary school shall give, but rather to build the best possible education upon such foundations as is actually furnished in the secondary schools. The second plan, namely, that of prescribing for entrance merely a year of work in some science, and then offering in college beginners' courses in all sciences for the benefit of those who do not offer the first courses for entrance, is one which is rapidly gaining adherents among the better schools of the country. From my point of

view then the proper machinery for the correlation of high school and college physics is: (1) the setting up of a norm by secondary school men for a first course; (2) the full recognition of this norm by college men and the adaptation of their courses to the *continuation* not the repetition of the work begun in the first course.

It only remains to point out what, in my judgment, should be the character of this first course, whether given in the high school or in the college, and what the character of the second course. It seems to me obvious that every good first course in physics should be *a fairly extended survey course*. It should be thorough in the sense that the principles of physics of the first order, not those of the second or third order, should be clearly stated and their most direct and simple applications clearly understood by the pupils. It should most emphatically not be thorough in the sense that a relatively small number of topics is exhaustively studied or that any particular topic is turned over and looked at from every possible point of view. All these are obviously the functions of *advanced* courses. In a word, the function of a first course is *to open up the field*. In such a course we should be particularly careful, I think, not to commit what has perhaps been the greatest mistake of the past two decades in beginning courses in physics, namely, the mistake of attempting to carry our pupils so far into the details and subtleties and refinements of the subject that they lose sight of the woods on account of the trees. The course should not be so intensive as to destroy perspective, nor so restricted as to fail to leave upon the student's mind a vivid picture of what is the extent of the field covered by the subject, what is the method which it uses, and what are the foundation principles which underlie it. So much for the character of a first course, whether it be given in the high school or in college.

The second course in physics will assuredly not be a survey course if the first course has been such. It will take up the subject more in detail. It will be more intensive, more mathematical, more analytical. There is no reason why the materials of the two courses need overlap to any appreciable extent. The college course will have all it can do to develop the formulæ and analyze the problems which high school physics cannot in the nature of the case touch upon at all; for example, in mechanics, the formulæ of impact, of simple harmonic motion,

those relating to moments of inertia, to centrifugal force, to the compound pendulum, to the ballistic pendulum; in electricity, to the Wheatstone bridge, to capacity determination, self-induction measurements, to the finding of magnetic constants, etc., etc. I need not specify further. The field is almost limitless. Since the student obviously needs a survey course as a prerequisite to such a course, it seems to me that the only thing for the colleges to do in physics is to do what they do as a matter of course in botany and in most of the other sciences; namely, to offer the beginners' course to the students who enter without having had this course in the high school. In other words the part which the colleges have to take in the correlation of high school and college physics is to recognize the existence of high school physics and to rate it at its full value on the assumption that it is properly taught.

DISCUSSION OF PROFESSOR MILLIKAN'S PAPER.

By A. A. Upham,

Whitewater (Wis.) State Normal School.

He said in part:

"I do not think there is much need of my discussing this paper, because I am heartily in accord with most of it. We have all of us, and I as much as anyone, spent our days and nights devising experiments and endeavoring to get apparatus in sets that pupils might perform quantitative experiments. While I am in favor of some quantitative experiments, it seems to me we have ignored the facts in the development of children; we have forgotten that the boy of high school age has much more interest in seeing things go than he has in measuring things accurately. It is a fact that some of our greatest physicists, Clark Maxwell and Tyndall, were not, as boys, interested in the quantitative aspect of physics. We have gone so far in omitting the quantitative experiments, spectacular, if you please, that we have squeezed the juice of interest out of the whole subject. We have emphasized the mathematical part to the exclusion of the practical and human interest. We have allowed the colleges to dictate courses in the face of the fact that a very small per cent of the high school pupils go to college. The high school courses should be planned with reference to the mental condi-

tion of high school pupils, and not necessarily with a view of fitting boys for college. The colleges disclaim any intention or desire to plan the work, and they probably are right in their claim, but nevertheless, from a desire to get on to the accredited list, many high schools have shaped their courses as they have felt necessary from the coercion of the inspectors.

DISCUSSION. By JOHN F. WOODHULL, *Columbia University.*

Reflection brings us to the conclusion that all of our colleges, east and west, are *public* and that education must be made continuous from high school to college. The gap between them which had a very natural origin is now being closed by the force of public opinion. The college must come down and articulate with the high school, and no so-called standards will be allowed to interfere. College entrance examinations are doomed. They are no test for scholarship, since no faculty can pass its own examinations. No one can pass them except those who have recently crammed for them. Cramming the memory is condemned by all educators and the ability to pass an examination is purely an accident and not a mark of scholarship. At least no examination has yet been found which will test one's knowledge.

The articulation between high school and college will be completed by three means:

First, such conferences as this one between college and high school teachers. They are now being held in increasing numbers all over the country.

Second, the visitations of the high schools by representatives of the colleges—not for purposes of standardizing them, but for the enlightenment of ignorant college professors. If they visit schools they may get their eyes open.

Third, the preparation by the colleges of genuine teachers for the high schools—instead of research specialists.

Four fifths of the membership of this association are secondary school teachers, and I say to you, you have a right to infer from the printed reports which the colleges publish that what they want most of all is large numbers of students. Now you have the goods, and with ordinary business sagacity you may dictate the terms.

A MEANS OF SHOWING THE CIRCULAR MAGNETIC FIELD ABOUT A WIRE.

By William Butler,

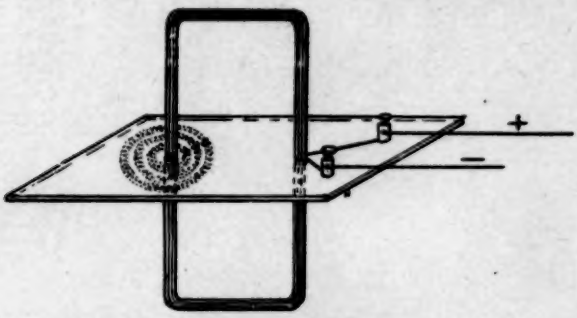
McKinley High School, St. Louis, Mo.

Probably most of us have had trouble in making this clear to a class, because the current required for successful demonstration is large.

A trial made with the apparatus here described shows that the lines may be made clear and distinct in the following way (see cut):

A piece of double strength window glass was cut 4″x10″ and round holes drilled, as shown, by using the corner of a broken file, wet with turpentine and camphor, in the familiar way. As soon as the glass was pierced the hole was made round by using a rat tailed file in the same way.

The glass was then put into a vise, and two wire nails were driven in the top of the bench, about 4″ back of the glass. A length of No. 24 D. C. C. magnet wire was then cut off, and with help from an assistant was wound through the holes and around the nails, so as to make a coil of about 30 turns.



Since the strength of the magnetic field depends on the number of "amphere turns," and the resistance of the coil was found to be only 1.32 ohms, it is obvious that enough current may easily be sent through this coil to produce a strong field.

Having a "battery charging" rheostat, and 110 volt current available, about 8 amperes or current was sent through the coil. Upon sifting iron filings on the glass and tapping, a well-defined field was at once obtained. The diameter of the field on each side of the coil was about 3″, and the lines at the center of the coil were parallel, as is usual.

THE ACCELERATION OF FALLING BODIES IS INDEPENDENT OF THEIR DENSITIES.

By E. J. Rendtorff,

Lake Forest Academy, Lake Forest, Ill.

Elementary students find it difficult to conceive that the rate of falling, when there are no retarding forces, is independent of the weight of the body. They know that two heavy solids will fall equally fast when dropped from the same height, but the behavior of a feather seems to indicate that very light bodies fall slowly. The proof that very light bodies fall with exactly the same acceleration as heavy ones is best illustrated by the time honored experiment of dropping a feather and a coin in a glass tube from which the air has been exhausted. The trick of the experiment is to invert the tube rapidly, so that the two bodies have an equal start and do not rub against the sides of the tube during their fall. This is not readily accomplished.

In determining the laws of falling bodies Galileo retarded the velocity by having the bodies roll down an inclined plane. In place of the solid a liquid can be employed whose fall is retarded, not by an inclined plane, but by allowing it to flow through an orifice of such nature that the retardation due to viscosity is small. Viscosity would produce the same effect as friction on the inclined plane.

The velocity of flow of a liquid through an orifice is calculated from the equation $v=K\sqrt{2gh}$ and is thus independent of the density of the liquid.

The equation is perfectly general, holding for all cases of falling bodies, whether solid or liquid and of large or small density.

The apparatus for this demonstration is illustrated in the accompanying diagram. In the bottom bulb is a small hole, D, of about 1.5 mm. diameter. The entire apparatus is 16 cm. long and the bulb C of 3.2 cm. diameter. It is filled by placing D in the liquid under consideration, opening the stop cock B

and exhausting the air until the apparatus is filled. On inverting the liquid in the upper tube A is removed.

The apparatus is now held vertically, the stop cock opened, and the time required to empty the vessel to the mark E noted. Water and mercury were generally employed, and the time of flow for each was practically 22 secs.

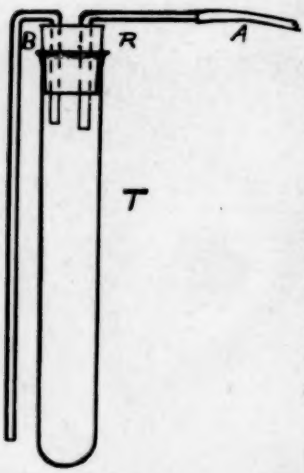
The liquids fall through the hole in accordance with the general laws of falling bodies, and, as the acceleration is independent of the density, the vessel is emptied in equal times no matter what liquids are employed, provided we confine our trials to those whose relative viscosities are not far different.

This experiment lends itself very readily to lantern demonstration.

STEAM TRAP FOR LATENT HEAT OF VAPORIZATION.

By R. O. Austin.

Central High School, Columbus, Ohio.



This simple style of trap has probably been used by others, and found serviceable; but the writer has never noticed it in other laboratories, and it may therefore be helpful to some.

It consists of an ordinary 6-inch test tube with a two-hole rubber stopper that fits tightly. Steam enters from the boiler at A, and leaves by the long arm B. To protect the calorimeter from the heat pieces of asbestos or card board should be inserted between it and the test tube.

Some of the advantages of this simple device over those commonly seen are:

(1) It hangs upon the side of the calorimeter and is thus self-supporting.

(2) It may be handled when hot by means of the projecting rubber stopper.

(3) It delivers the steam to the bottom of the water.

(4) The space for further condensation of steam after leaving the trap is reduced to a minimum.

(5) The supply of steam to the water is easily discontinued by quickly lifting the trap.

AN ACCELERATION APPARATUS.

By L. E. Akeley,

University of South Dakota, Vermillion.

The acceleration apparatus described below has given better satisfaction than any of the standard forms of the apparatus.

A weight of one kilogram is attached to the end of a string. A small metal ball weighing 11 grams and 1.5 cm. in diameter is attached to the other end. The string is placed over a pulley. The kilogram weight falls through a measured height. The small ball moves along the surface of a table horizontally.

At the instant that the kilogram weight strikes the floor, the small weight leaves the edge of the table and begins its motion as a projectile with both horizontal and vertical components. A small metal rod is placed at various heights, at various distances from the edge of the table. The collision of the small ball with the rod shows the path of the projectile. Figure 1 shows such a path and table 1 gives the values as measured and calculated. Figure 2 is a sketch of the apparatus.

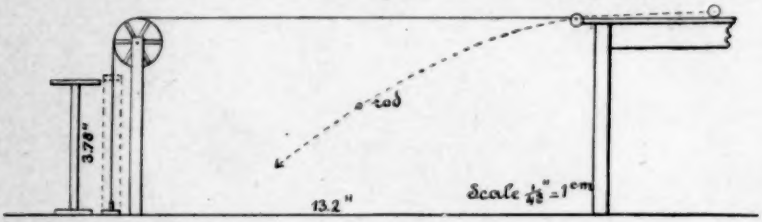


Fig. 1.

The kilogram weight fell through a height of 60.5 cm.

Column 1 gives the distance of the rod from the edge of the table measured horizontally. Column 2 gives the vertical distance of the rod from the floor. Column 3 gives the vertical fall. Column 4 gives the calculated values corresponding to column 1.

1	2	3	4
74.5	63.9	23.6	75.3
88	55.3	32.2	88.06
97.8	47	40.5	98.72
115	33	54.5	114.6
119.5	27	60.5	120.7
123.7	23.7	63.8	123.8

The string used should be a light one; cotton thread was used in this case. Careful adjustment must be made so that the small ball will leave the table at the instant the large weight strikes the floor. The mass of the small ball and that of the pulley are negligible in comparison with that of the large weight. The diameter of pulley is 20 cms.

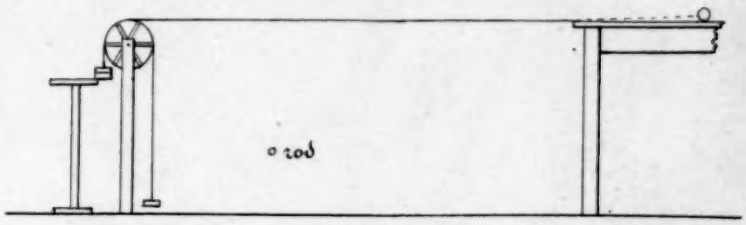


Fig. 2.

Advantages of this form of acceleration apparatus.

1. An inspection of the curve obtained with the apparatus will fix for the student some of the fundamental laws of motion preliminary to the deduction of the formula.

For example, an inspection of the curve in Figure 1 shows that at the point A the small ball has fallen through the same height, 60.5 cm., as that through which the large weight fell. The figure shows further that the direction of motion at this point makes an angle of 45 degrees with each axis. The horizontal and vertical components are therefore equal. The small ball has the same horizontal component to its velocity as it had when it left the table. In other words the horizontal component of the projectile's velocity is uniform. This makes it possible to treat the distances measured on the abcissas as proportional to the time of fall and an inspection of the curve will give the formula

$$S = \tfrac{1}{2}at^2.$$

Besides if the student sees that the motion at right angles to the moving force is a uniform motion he grasps the fundamental principle underlying the above formula, viz., that the moving body retains during each interval all the velocity imparted to it during preceding intervals.

Again allow the large weight to fall through a height of one meter. Place the rod so that when the ball strikes it, it will have fallen one meter. By a few trials the student finds that the rod must be placed at a distance of two meters measured

horizontally from the table. Other distances are taken and it is found that the horizontal distance in each case is double the vertical distance. In other words, the final velocity of a body falling from rest is double the average velocity during the fall. This result is certainly very useful in the discussion which should follow this experiment and the deduction of the laws of accelerated motion.

2. The apparatus also illustrates the motion of projectiles. The setting of the rod at calculated positions affords a very satisfactory confirmation of the laws governing the motion of projectiles.

3. The apparatus can be used equally successfully to illustrate the relations between force, mass and acceleration.

For this purpose a weight of 1½ kilograms can be placed on one end of a string and ½ kilo. on the other end. Both are placed over pulley. The third light string passes over pulley connecting the heavier weight with the light ball. The rod is struck by the ball just as in the former case.

Figure 3 shows the arrangement of apparatus. This gives results just as satisfactory as the former ones.

SOUTHERN CALIFORNIA ASSOCIATION.

The first meeting of the Southern California Science Association was held at Occidental College, Los Angeles, Saturday, December 12. The meeting was well attended and the enthusiasm created vouches for long life to the new association. The meetings were all held in the assembly hall of the main building. The first session was opened by an address of welcome from President John W. Baer, of the College; this was followed by an address by Dean A. H. Chamberlain, on the "Tendency of Science Instruction in College and Value of a Course in General Science in the Secondary School." An interesting general discussion followed, led by G. C. Bush, of South Pasadena, and Miss Mary Ross of Occidental Academy. After luncheon the laboratories were inspected. The afternoon session was opened by an address on "Correlating Science Teaching with Practical Experience," by R. C. Daniels, of the Los Angeles High School. The discussion was led by H. L. Twining, Polytechnic High School, and W. K. Gaylord, Throop Polytechnic Institute. At the close a business meeting was held.

The officers are: President, Professor W. A. Fiske, Occidental College, Los Angeles; Vice-president, Professor W. R. Bowker, University of Southern California, Los Angeles; Secretary-Treasurer, H. T. Clifton, Throop Polytechnic Institute, 871 Lake Ave., Pasadena.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

144. Two quantities vary directly and inversely as x, respectively. If their sum is equal to 7 when $x = 2$, and to -13 when $x = -3$, what are the quantities?

Solution by A. M. Harding, Fayetteville, Ark.

Let mx and k/x be the numbers. Then from the conditions of the problem we have $2m+k/2=7$ and $-3m-k/3=-13$. $\therefore$ $m=5$, $k=-6$, and the numbers are $5x$ and $-6/x$.

145. *Proposed by W. T. Brewer, Quincy, Ill.*

Reduce to a quadratic equation and solve $x^3-42x^2+587x-2730=0$.

I. Solution by Chas. M. Field, Locust Dale, Va.

The prime factors of the absolute term are 2, 3, 5, 7, 13. By trial 13 is found to be a root. This gives $x^2-29x+210=0$ for the depressed equation. Factoring, $(x-14)(x-15)=0$; whence the required roots are 13, 14, 15.

II. Solution by Camille Dickerson, Richmond, Va.

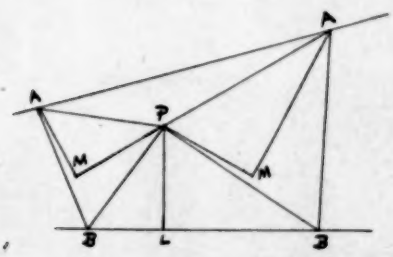
The given equation may be written in the form: $x^3-42x^2+558x-2744-x+14=0$. Therefore $(x-14)^3-(x-14)=0$, $(x-14)[(x-14)^2-1]=0$. From this one easily finds that $x=13, 14, 15$.

Geometry.

146. *Proposed by E. E. Wood, Fort William, Ontario.*

Given two intersecting straight lines and a point P not on either line. Draw an equilateral triangle with one vertex at P, the others, one each, on the given lines.

Solution by E. L. Brown, Denver, Colo.



Let BB, AA be the two given lines, and P the given point. Draw PL perpendicular to BB. Construct LPM=60°, and PM=PL. Draw MA perpendicular to PM, take LB=MA.

The right triangles PLB and PMA are equal, since PM=PL, and LB=MA. Therefore PA=PB, and angle LPB=MPA. Therefore APB = MPA + MPB = LPB + MPB = LPM = 60°. Hence the triangle APB is equilateral.

147. *Proposed by Walter L. Brown, Fancher, N. Y.*

Given the perpendiculars from the vertices of a triangle upon the opposite sides to construct the triangle.

Solution by O. R. Sheldon, Chicago, Ill.

Let p, p_1, p_2 be the given perpendiculars from the angles of the required triangle ABC, on the sides a, b, c, respectively. Then $b=pa/p_1$, $c=pa/p_2$. Therefore the sides are proportional to 1, p/p_1, p/p_2. With the latter values construct the triangle ADE. From A draw AH$=p$, perpendicular to DE and at the point H a line FG parallel to DE. Produce AD and AE to intersect FG in B and C. ABC is the required triangle.

Miscellaneous.

148. *Proposed by H. E. Trefethen, Kent's Hill, Maine.*

A roofer is making an open gutter with the sides each 4 inches in slant height and the level bottom 4 inches across. What shall be the distance between the sides at the top in order for the gutter to carry the largest volume of water?

Solution by H. E. Trefethen, Kent's Hill, Maine.

I. Let ACDB be a cross section of the gutter, AB the required distance. To determine AB so that the area of the quadrilateral ACDB may be a maximum, complete an equilateral hexagon by joining AC′D′B to the side AB. Evidently when each quadrilateral is a maximum the whole figure is a maximum, and the parts are equal, for otherwise the smaller might be increased without increasing the length of any of the equal sides. Thus ACDB is half the maximum hexagon whose sides each $= 4$ inches. But the hexagon is a maximum only when it can be inscribed in a circle. Therefore AB $=$ 8 inches.

II. (1) Put $z =$ the angle made by a side with the horizon. Then $4 \sin z =$ the Alt., $16(\sin z \cos z + \sin z) =$ area of cross section, $\sin z \cos z + \sin z =$ max., $f'(z)=\cos^2 z-\sin^2 z+\cos z=0$, $\cos z = \frac{1}{2}$ or -1, $z = 60°$ or $180°$. The former corresponds to the maximum, the latter to the minimum. Hence the required distance is 8 inches.

(2) Let $x =$ the required distance. Then $\frac{1}{4}(x+4)(48-x^2+8x)^{\frac{1}{2}}$ $=$ area of cross section.

$$f'(x) = \frac{(x+4)(4-x) + (48-x^2+8x)^{\frac{1}{2}}}{(48-x^2+8x)^{\frac{1}{2}}} = 0,$$

$x = 8$ or -4. The former gives the maximum area $= 12\sqrt{3}$, the latter gives the minimum area $= 0$.

CREDIT FOR SOLUTIONS RECEIVED.

Algebra 139. Hamlet P. Collins. (1)

Geometry 141. G. E. Congdon. (1)

Algebra 144. W. H. Albrecht, T. M. Blakslee, Wm. B. Borgers, E. L. Brown, Walter L. Brown, Hamlet P. Collins, G. E. Congdon, Chas. M. Field, A. M. Harding, F. S. Heinaman, Louis Lindsey, Orville Price, O. R. Sheldon, H. E. Trefethen, Jas. H. Weaver, I. L. Winckler, E. E. Wood, G. B. M. Zerr. (18)

Algebra 145. W. H. Albrecht, Wm. B. Borgers, E. L. Brown, W. T. Brewer, Walter L. Brown, Hamlet P. Collins, Camilla Dickerson, Chas. M. Field, A. M. Harding, F. S. Heina-

man, Louis Lindsey, Orville Price, M. H. Pearson, Gertrude L. Roper, O. R. Sheldon, H. E. Trefethen (3 solutions), Jas. H. Weaver, W. H. Weslar, I. L. Winckler, E. E. Wood, G. B. M. Zerr. Also one incorrect solution. (24)

Geometry 146. T. M. Blakslee, E. L. Brown, Walter L. Brown, G. E. Congdon, B. C. Eastham, Orville Price, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (9)

Geometry 147. E. L. Brown (2 solutions), Walter L. Brown, G. E. Congdon, B. C. Eastham, A. M. Overholt, M. H. Pearson, O. R. Sheldon, H. E. Trefethen, I. L. Winckler, E. E. Wood, G. B. M. Zerr. (12)

Miscellaneous 148. W. H. Albrecht, T. M. Blakslee (5 solutions), Wm. B. Borgers, E. L. Brown, R. A. Brown, Walter L. Brown, Hamlet P. Collins, G. E. Congdon, Jno. A. Hodge, Louis Lindsey, Orville Price, R. W. Rogers, O. R. Sheldon, H. E. Trefethen (2 solutions), Jas. H. Weaver, James H. Whitted, I. L. Winckler, E. E. Wood, G. B. M. Zerr. (24)

Total number of solutions, 89.

PROBLEMS FOR SOLUTION.

Algebra.

155. *Proposed by I. L. Winckler, Middlebury, Vt.*

A purse contains five dimes, one of which is marked; another contains five unmarked dimes. Four coins are taken from the former and put in the latter; and then four are taken from the latter and put in the former. Find the probability that the marked dime is still in the first purse.

Geometry.

156. *Proposed by John J. Quinn.*

AB is equal and perpendicular to BC; D and E are their midpoints. On AB as a diameter describe a circle. Draw CD to cut the circumference in F and F'. Draw EF' cutting AB in M, and EF produced to meet AB produced in M'. Prove that M'A : M'B = MA : MB.

157. *Proposed by W. T. Brewer, Quincy, Ill.*

A conical cup 6 inches high and 5 inches in diameter is one fifth full of water; what must be the diameter of a ball dropped into the water that shall just be immersed by it?

158. Through a given point P, to draw a line perpendicular to a given plane.

Miscellaneous.

159. *Proposed by C. M. Woodward, Washington University, St. Louis, Mo.*

A room (without windows or doors to interfere) is 30 feet long, 12 feet wide, and 12 feet high. An electric wire is to be carried, along the ceiling, walls or floor, from a point one foot below the ceiling in the center line of one end, to a point one foot above the floor in the center line of the other end. Required the shortest route and its length.

Applied Mathematics.

160. *Proposed by W. A. Challacombe, Carlinville, Ill.*

A cord 6 feet long is secured at A and B, 3 feet apart horizontally, and sustains a weight w, attached at C. What must be the length of AC that the tension of AC shall be twice the tension of BC?

REAL APPLIED PROBLEMS IN ALGEBRA AND GEOMETRY.

COMMITTEE ON INVESTIGATION:
JAMES F. MILLIS, *Chairman, Francis W. Parker School, Chicago.*
JOS. V. COLLINS, *State Normal School, Stevens Point, Wis.*
C. I. PALMER, *Armour Institute of Technology, Chicago.*
E. FISKE ALLEN, *Teachers College, New York, N. Y.*
A. A. DODD, *Manual Training High School, Kansas City, Mo.*

Teachers of mathematics and all others who are interested in the movement to reform the teaching of mathematics in the secondary schools by teaching the subjects more in relation to their practical uses are earnestly requested to co-operate with this committee of the Central Association of Science and Mathematics Teachers in the attempt to collect for use in secondary schools the *real applied problems of elementary algebra and geometry* in the various trades, industries, and sciences, and to determine the extent to which such problems exist in the various fields. Teachers are asked to consult practical men engaged in the various trades, to search through trade journals and books on the various practical pursuits and sciences, for real applied problems, and to send the problems to this committee for publication in these columns, so that all teachers of secondary mathematics may have the benefit of them for class room use.

All real applied problems of algebra and geometry that are sent to the members of the committee will be printed in these columns, and proper credit given the contributor.

Teachers are requested to try these problems in their classes, great care being exercised in their presentation, and to forward criticisms to the committee based upon the results.

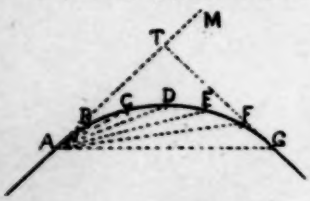
PROBLEMS.

By William E. Stark, Ethical Culture School, New York City.

1. To measure the height of a church spire which cannot be conveniently approached. An observer plants vertically a staff 10 ft. long successively at two points A and B, in line with the spire, and 30 ft. apart. For each position of the staff, the observer takes such a position that the top of the staff and the top of the spire are in line with his eye. Supposing his two positions to be respectively 6.3 ft. and 7.6 ft. from the staff, and the height of his eye above the ground to be 5.4 ft., calculate the height of the spire and its distance from the nearer position of the staff.

(Suggestion. This is a good application of simultaneous equations.)

2. In laying out a curve in a railroad survey, stakes are set 100 ft. apart. In the figure, which represents such a curve, the chords AB, BC, CD, DE, EF, FG each equals 100 ft. These stakes are usually set as follows: The proper angle TAB is laid off from the tangent AT, and 100 ft. is measured on line AB thus locating point B, then angle



BAC is laid off and an arc with center at B and radius 100 ft. is made to intersect AC, thus fixing point C. In the same way each successive point is found by laying off the proper angle and finding the intersection of its side with an arc whose center is the stake last set and whose radius is 100 ft.

Show that (1) since the curve is to be the arc of a circle, angles TAB, BAC, CAD, DAE, ... are equal; (2) each of these angles is equal to one half the central angle subtended by a 100-ft. chord.

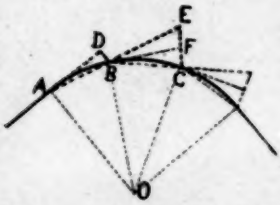
By J. F. Millis, Francis W. Parker School, Chicago.

3. In the railroad curve in the preceding problem, show that the sum of the "deflection angles" TAB, BAC, ... equals one half of the "intersection angle" MTG, the angle between the tangents at the ends of the road curve. Show that the intersection angle equals the central angle subtended by the curve.

4. To find the length of the railroad track in a curve (See fig. of Prob. 2) with a given intersection angle, the curve to be of given "degree." The degree of a curve is determined by a central angle which is subtended by a chord of 100 ft. Suppose the intersection angle to be 34° 20′, and the curve to be a 6° curve. (Suggestion. 34° 20′ = 34.333°. Since each central angle of 6° will subtend a 100-ft. chord, the number of chords will be 34.333° ÷ 6°.)

Find the length of a 10° curve whose intersection angle is 58° 40′.

5. Surveying railroad curves by "tangent and chord deflections."

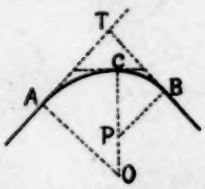


If AD is tangent to the railroad curve ABC; AB, BC, ... equal chords; and BD is perpendicular to the tangent AD from the curve; then BD is the "tangent deflection" of the curve. If chord AB is produced to E, making BE = AB = BC, the distance CE is the "chord deflection."

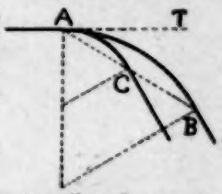
Show that (1) the tangent deflection equals one-half the chord deflection; (2) if the length of chord is c and radius R, chord deflection = c^2/R; (3) tangent deflection = $c^2/2R$.

(Suggestion. Draw BF tangent at B. Triangles BCE and BCO are similar.)

6. In railroad construction, where it is desirable to secure easement in a curve by making the degree of curvature less at the beginning of the curve than farther along, "compound curves" are used. A compound curve is made up of two or more arcs of circles with radii of different lengths, and having common tangents at their junction points.



Show that the intersection angle at T equals the sum of the central angles of the arcs AC and CB in the compound curve ACB.

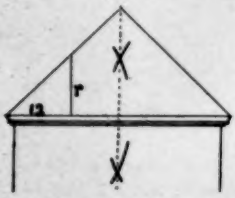


(Suggestion. Draw the common tangent at the junction point C.)

Show that this rule holds for a compound curve of three or more arcs.

7. The following principle is used in laying out railroad curves:

If the curves of two tracks begin at the same tangent point and end in parallel tracks, (1) their chords coincide in direction, and (2) their chords are proportional to their radii. Demonstrate this.

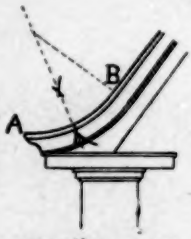


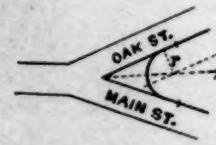
(Suggestion. Prove angle CAT = angle BAT.)

By Ben J. Lubschez, Architect, Kansas City, Mo.

8. Problem. To draw a symmetrical roof on MN, pitch r inches to the foot. The figure suggests the construction.

9. Problem. (See figure.) To draw easement of cornice tangent to rake cornice at B, and passing through A. (Suggestion. Since the arc passes through A and B, upon what line must its center lie? Since the arc is tangent to rake cornice at B, upon what line must its center lie?) This construction is used also in laying out the easements of stair rails.





10. Problem. To draw the connecting curve, such as the line of the front of a building, of established radius r and tangent to two intersecting lines.

(Suggestion. Upon what loci must the center lie?)

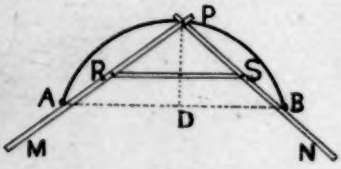
By Jos. V. Collins, State Normal School, Stevens Point, Wis.

11. To mark by means of a carpenter's square a board of any width that is to be cut into any number of equal strips. Suppose board is 11½ in. wide and is to be cut into 4 strips of equal width. Lay heel of square on one edge and turn until 12 mark is on other edge. With awl make marks at 3, 6, 9. Move square and repeat performance. Then draw lines through marks made.

Justify the method.

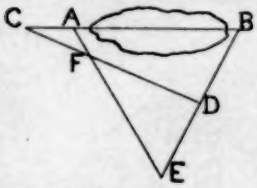
12. To construct a trefoil (very frequently used in architectural adornment, especially Gothic architecture) where the radius of one of the circles is given.

13. To construct the arc of a circle mechanically when it is inconvenient to find its radius. Let AB be the chord of an arc APB, and PD the sagittus or height of the segment. Drive nails at A and B. Then nail three wooden strips PM, PN, and RS together so that P is at the apex of the segment and PM and PN touch A and B, respectively. Show that by sliding MPN around, having it constantly touch A and B, point P will trace the arc of the circle.



14. Method for finding distance AB when the ground in triangle FED is bad. Set a stake C in line with AB prolonged; set another stake D so that C and B can be seen from it; and a third stake E in line BD prolonged so that DE = BD. Set a fourth stake F at the intersection

of EA and CD. Measure AC, AF, FE. Show that AB is a fourth proportional to AF, AC, and FE — AF.

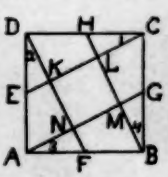


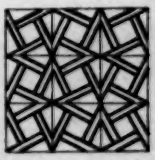
15. An architect desires to put 6 rooms and 3 hallways, the latter each 8 ft. wide, into an outside length of 119 ft. in such a way that each room from the front back shall be 1 ft. narrower than the one in front of it. The outer walls are 18 in. thick and the inner ones 6 in. What will be the inside lengths of the respective rooms?

16. A farmer wishes to divide a double tree 4 ft. 6 in. long, for three horses, so as to make the longer arm 2 in. longer than twice the shorter arm. Where should the large clevis be placed?

By Miss Mabel Sykes, South Chicago High School, Chicago.

17. This parquet floor design is based upon the drawing that accompanies it. In the drawing E, F, G, H are the middle points of the sides AD, AB, BC, CD, and the points joined as shown. Show that KLMN is a square. Find by algebra the relation between the areas of the large square AC and the square LN.





Computation: Let AB = a.

Then AF = $a/2$.

DF = $a\sqrt{5}/2$.

Triangle AFN is similar to ADF.

Hence AN = $a\sqrt{5}/5$ = DK.

NF = $a\sqrt{5}/10$.

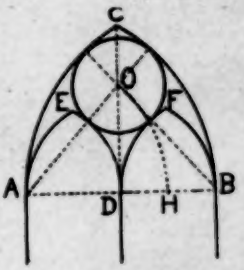
Hence KN = $a\sqrt{5}/5$.

Area of KM = 1/5 of area of AC.

The geometrical problem may be varied by drawing lines CE, DF, AG, BH so that the angles 1, 2, 3, and 4 are equal. Then the computation becomes trigonometric.

Note. This figure is said to have been used by a Hindu, Bhaskara, born 1114 A. D., to prove the Pythagorean theorem. The design was used also in Arabic lattices. See Cajori's History of Elementary Mathematics.

18. This is a drawing of one of the earliest of Gothic tracery windows. The arch ABC is based on an equilateral triangle. A is the center and AB the radius for the arc CB, and B the center and AB the radius for arc AC. D is the center of span AB. The arches AED and DFB are drawn on the half span by similar construction. Find the center and radius of the circle with center O that shall be tangent to the four arcs DE, DF, AC, CB.



(Suggestion. With A as center and AH as radius cut the altitude CD at O. H is center of DB.)

If this problem is preceded by a full discussion of the following exercises, the class will find point O without assistance:

(a) Every point in the common tangent to two equal tangent circles may be the center of a circle tangent to the two given circles.

(b) Every point in the common chord to two equal intersecting circles may be the center of a circle tangent to the two given circles.

(c) Every point in the perpendicular bisector of the line of centers of any two equal circles may be the center of a circle tangent to the two given circles.

(d) Every point in the circumference of a circle concentric with two given concentric circles and lying half way between them may be the center of a circle tangent to the two given circles.

MORE COMMENTS.

By G. W. Greenwood, Dunbar, Pa.

In the January number of School Science and Mathematics, page 40, it is suggested that "if a postulate leads to * * * no fruitful scientific hypothesis" it has no *real* or objective meaning. It would of course be impossible to determine beforehand the value of a new and untried hypothesis, nor should we decide too hastily that a postulate is fruitless; negative numbers were at first called imaginary, or fictitious, and regarded merely as curiosities; complex variables, I believe, were found to be of real service in theoretical electricity; the pure study of conic sections, after centuries of comparative inutility, has become the corner stone of mathematical astronomy; "that a quantitive study of defective children should need the study first of the geometry of hyperspace may sound paradoxical, but it is none the less true"* ; when Pasteur took up the subject of spontaneous generation his friends expressed their regret at his wasting energy on a "useless theory," yet upon the unforeseen results rest vast advances in medicine and surgery. Instances could be multiplied almost without number showing that only omniscience could decide that any postulate was useless.

In fact, so prone are we to estimate relative values by proximate concrete returns that teachers should incline all the more strongly to emphasize the importance of research promising no immediate material rewards.

Again, whether in the election of a president or in the most trivial act calling for a conscious or unconscious exercise of reason, in making a postulate or a deduction from it, one's mental activity should be guided and strengthened by a proper study of geometry. Unfortunately, the subject as currently presented is a most potent agency in dulling whatever reasoning powers the student may initially possess.

*"Grammar of Science," Karl Pearson. I am indebted for this quotation to Dr. H. L. Reitz of the University of Illinois.

INTERNATIONAL COMMISSION ON THE TEACHING OF MATHEMATICS.

The American members of the International Commission on the Teaching of Mathematics whose appointment was announced in the February number of SCHOOL SCIENCE AND MATHEMATICS, held their first meeting in New York in March, and organized by electing Commissioner Smith as Chairman and appointing Miss S. M. Neilson as clerk.

SCHOOL SCIENCE AND MATHEMATICS was adopted as official organ in the sense in which official organ is defined in the Preliminary Report of the Central Committee, (see SCHOOL SCIENCE AND MATHEMATICS, p. 106).

It was decided to form an Advisory Council to which important general questions may be referred and to invite to membership: The United States Commissioner and Ex-commissioner of Education, the Presidents of Harvard, Columbia and Chicago Universities, and the Presidents and Ex-Presidents of the American Mathematical Society and of the American Federation of Teachers of Mathematical and the Natural Sciences.

A plan of work by means of a system of Committees and Subcommittees was prepared and submitted to the Advisory Council. It is expected that the Preliminary Report of the American Commissioners will be ready for publication in the June number of SCHOOL SCIENCE AND MATHEMATICS.

CENTRAL SCIENTIFIC COMPANY NEW CATALOGUE.

We believe that it will be of interest to our readers to know that the Central Scientific Company of Chicago has just issued its new "1909 Catalogue of Physical and Chemical Apparatus," which has been in process of preparation and completion for the past eighteen months. Examination of advance sheets submitted to us indicates the utmost care and thoroughness in preparation. The careful and scientific classification and topical arrangement of apparatus add much to its convenience. A notable advance has been made over previous catalogues in the following respects:

1. The omission of numerous pieces that are obsolete, or of doubtful utility.
2. The large number of new pieces and improved forms of existing pieces of apparatus found therein.
3. The definite technical descriptions and exact specifications as to efficiency of apparatus, often supplemented with practical suggestions as to the method of operation.

This catalogue is considerably larger than their former catalogue, being 10¼x5¾", containing 400 pages profusely illustrated with new high grade engravings; sewed binding, which permits it to remain open and flat while in use. We feel assured that it will be welcomed by the Science Teachers as a valuable acquisition to the Science Library.

SCIENCE QUESTIONS.

FRANKLIN T. JONES,

University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE *are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

QUESTIONS AND PROBLEMS FOR SOLUTION.

9. *Proposed by Thomas Anderson, Cleveland, Ohio.*

How many pounds of 60° sulphuric acid can be raised to 66° acid by the SO_3 formed from 10,000 lbs. of sulphur? [60° acid is 77.67% H_2SO_4; 66° acid is 93.19% H_2SO_4.]

10. *Proposed by O. R. Sheldon, Chicago, Ill.*

The drawing power of a locomotive is only one half its own weight, but it can start a train of cars which requires a force many times greater than that. How and why?

11. In what sense are the mass, the inertia and the quantity of matter of a body synonymous terms?

SOLUTIONS AND ANSWERS.

1. Is the secondary school teacher in science hampered or assisted in his work by the college entrance requirements? Are the latter of the right kind? Do they prevent a teacher from doing pretty much as he pleases?

Remarks by G. B. M. Zerr, Philadelphia, Pa.

The great underlying principles, the vital points of all science teaching are the same for every live teacher. Whether the student in the secondary school is preparing for college or for his lifework, these principles should be his foundation knowledge. Therefore there is no reason why the teacher should lose his individuality in properly teaching his subject.

Remarks by Chas. H. Korns, Bradford, Pa.

I do not know that I am hampered by the college requirements to any serious degree. However, I have noticed this—pupils elect other courses, avoiding physics when possible on account of the quantitative experiments and numerical problems.

If the list from Columbia University published in the March number is a sample, I think the college entrance questions are too mathematical. We ought not to be expected to teach "applied mathematics" in the high school.

2. *Proposed by O. R. Sheldon, Chicago, Ill.*

A nail can be driven into an elastic body with a wooden mallet, but not with an iron hammer. Why?

Solution by G. B. M. Zerr.

It is much easier to drive a nail into an elastic substance with a wooden mallet than with an iron hammer. Owing to the hardness of the iron the blow acts like an impulse while the wood acts like a

force active for a small interval of time. If a piece of wood is placed upon the nail and the wood struck with an iron hammer, the result will be nearly the same as driving the nail with the wooden mallet, but the head of the nail also pierces the wood. I have seen belt hooks driven into rubber belts with an iron hammer. The result is much more satisfactory if a piece of wood is laid upon the back of the hook and another under the belt and then the hook driven by striking the wood with an iron hammer.

3. *Proposed by J. Hawley Aiken, Saratoga Springs, N. Y.*

A uniform stick 24 cm. long, weighing 30 gm., has a piece of metal attached to one end. The stick then balances 5 cm. from this end. If the metal is submerged in water, it balances 5.38 cm. from the end. Find the specific gravity of the metal.

Solution by Gertrude Roper, Detroit, Mich.

Total weight of bar = 30 g.

Total length of bar = 24 cm.

Since a body behaves as though its mass were all at the center point, applying the doctrine of moments we have:

$30 \times 7 = 5 \times W_{air}$

$W_{air} = 42$g.

When w is in water

$30 \times 6.62 = 5.38 \times W_{water}$

$W_{water} = 36.91 +$ g.

By Archimedes' principle

42.—36.91+=5.09 g. wt. of water displaced

42÷5.09=8.25 specific gravity of w

5. *Proposed by O. R. Sheldon, Chicago, Ill.*

A ball bounds a finite distance, and, in each succeeding bound, rebounds one half the distance of the preceding bound. Will it ever come to rest?

Solution by Alfred Bjorkland, Michigan City, Ind.

Beginning with the first impact, the periods of time required for each succeeding bound make up the series,

$$t + \tfrac{1}{2}\sqrt{2}\,t + \tfrac{1}{2}t + \tfrac{1}{4}\sqrt{2}\,t + \tfrac{1}{4}t + \tfrac{1}{8}\sqrt{2}\,t + \tfrac{1}{8}t \ldots\ldots$$

where t is the time required for the first bound. The value of this series is $3.414t$, which is the time required for the ball to come to rest.

Note by Chas. H. Korns.

Theoretically the ball would never come to rest. Rest is its limit, and this is a case of a variable approaching a limit which it can never reach. But practically the ball would come to rest in a very short time. Theoretically there is no such thing as rest in the universe. As the molecules of matter are in constant vibration among themselves, so all bodies are in motion with respect to each other. But it takes a seismograph to detect it, so we say they are at rest. Thus it would be with the ball. Its motion would soon become negligible, and we would say it has come to rest.

CREDIT FOR SOLUTIONS RECEIVED.

1. G. B. M. Zerr, Chas. H. Korns, O. R. Sheldon. (3)
2. G. B. M. Zerr, O. R. Sheldon. (2)
3. A. Bjorkland, Michigan City, Ind.; Jno. A. Hodge, New Albany, Ind.; Chas. H. Korns, Bradford, Pa.; Gertrude Roper, Detroit, Mich.; A. Haven Smith, Seattle, Wash.; Frank G. Taylor, Oregon, Ill.; W. H. Weslar, Crockett, Cal.; G. B. M. Zerr, Philadelphia, Pa. (8)
5. A. Bjorkland, Jno. A. Hodge, Chas. H. Korns, G. B. M. Zerr. (4)

METRIC EQUIVALENTS FOR DRUGGISTS AND DOCTORS.

The Eastern Drug Co., Boston, has issued an interesting wall card on which are displayed the metric equivalents for apothecaries' weight, running from 0.064 g to nearly 250 g, expressed in prescription symbols instead of figures. It has liquid measure also from less than one cc to 1,000 cc. The card is 34x18 cm, and has over 100 equivalents, which are from English to metric and metric to English. R. P. W.

NEW PERIODICAL OF METROLOGY.

Journal of Weights and Measures. Editor, F. Reichmann, Sup't of Weights and Measures, State of New York. Associate Editor, D. C. Palmer, Commissioner of Weights and Measures, State of Massachusetts. Journal of Weights and Measures Pub. Co., Troy, N. Y. Monthly, $1.50 per year. Size, 27x18 cm. First issue Nov., 1908, 35 pp.

The object of this periodical is to educate the public on the underlying principles of weighing and measuring. Editorially it states: "The gross ignorance concerning weights and measures of the vast majority of people is something astonishing." After several illustrations it goes on: "These and a thousand other matters that involve measurement will be taken up by the *Journal of Weights and Measures*, and treated in a popular semi-technical style that will be readily understood."

Among the articles of No. 1 are: "Address of Hon. O. Strauss before the National Conference on Weights and Measures," "Work of the Bureau of Standards," "Trip Scales," "The Metric System, Linear Measures," "Newark Meeting of the New Jersey Sealers Association," "Weight of Various Commodities." A humorous page and a question box are added. The articles are illustrated by portraits, and otherwise.

The magazine is the official organ of the National Conference on Weights and Measures, and the Sealers Associations of New Jersey, New York, Massachusetts, Rhode Island, and Connecticut.

Without doubt this will be nonpartisan so far as concerns the system, but as both editors are understood to have decided leanings toward the International System—and who that knows it thoroughly has not?—we may expect the reading public to get some education on a subject which the public schools of the country are culpable in not giving. SCHOOL SCIENCE AND MATHEMATICS wishes the *Journal* much success. R. P. W.

COLORADO MATHEMATICAL SOCIETY.

Through the courtesy of the Science Section of the State Teachers' Association, the Colorado Mathematical Society held its fourth meeting for the year in the East Side High School, Denver, as one of the "Section Meetings" of the State Teachers' Association.

The Society was called to order by the president, Principal E. L. Brown, North Side High School, Denver.

The subject of the program was "Improvement in the Teaching of Geometry."

Prof. Chas. R. Burger, State School of Mines, presented a paper on this theme, which was followed by short talks.

Professor Burger said: A spirit of unrest and dissatisfaction with the mathematical output of our secondary schools is manifest by the periodical discussions on the subject, by the contributions in current literature, and by the report of the Geometry Committee of the Central Association of Science and Mathematics Teachers.

We all agree that something is wrong, but we are not sure whether the fault lies with the teacher, the text-book, or the whole educational system. Most of us read these articles and listen to these discussions, but make ourselves content by thinking they refer to our associate teachers, and we go into our own class rooms doing much the same old things that we have done for years.

Much harm is done the beginner in algebra or geometry by placing over him a poor or inexperienced teacher, or one whose specialty has been in another line. This work should be in the hands of a specialist, of one who has mastered at least the elements of the calculus, who is not overworked, who reads and investigates the subject matter and methods of teaching. Salaries now paid are not commensurate with the kind of work demanded.

Writers of text-books are not keeping abreast of the geometry movement. The question of rigor is overrated. There is too much hair splitting in definitions. Too many theorems proved that need no proof, and too much trying to crowd into a single year more than a child fourteen or fifteen years old can absorb.

Much useless material of proofs of propositions which the pupil has long believed to be true by intuition or experience might be eliminated and useful matter in the line of practical application might be inserted without injury to the logical development from the beginner's point of view.

The elaborate notation used in most text-books obscures the thread of logic. In most cases a line can be represented by a single letter or an angle by a character.

The report of the Committee on Geometry of the Central Association ought to be productive of much good. There is no necessity for the introduction of the word "congruent," the words "equal," "equivalent" and "identical" are satisfactory. It is not necessary to discard "circumference." "Ray" is a valuable addition to the pupil's vocabulary. With the assistance of "segment" and "ray" there is no danger of over burdening the word "line." "Sect" is unnecessary.

As regards the "undefinables," point, line surface, plane, whole, part, etc., leave them undefined, but have them discussed as to limitations and properties.

We should have a verbatim committing to memory of the theorems, definitions, and formulas of the text, as they are models of English as well as of mathematical conciseness. The formulas πR^2, $2\pi R$, $4\pi R^2$, $4/3\pi R^3$ and $\pi/6(B+b+4M)$ should be a part of the student's mental machinery.

Much work should be given in the application of these formulas. Pupils should be trained not to be afraid of long numerical problems, and they should have the ability to secure accurate results.

Professor Burger emphasized the necessity of accurately drawn figures, and illustrated the fallacy to which inaccurate construction might lead.

He recommended the introduction of that portion of trigonometry which deals with the mensuration of the plane triangle, because its application is useful and appeals to the student.

In regard to the treatment of limits, he would very much dislike to see a treatment of limits go from a text on elementary geometry. He would have the pupils made familiar with the theorems under limits. He would not attempt to give a formidable algebraic proof, but lead the pupil by illustration to see intuitively the truth of the theorem.

Quoting Professor Greenwood, Professor Burger closed by saying that "as far as geometry is concerned, it is safe to say that whatever changes occur will be in the direction of greater interest, more applied work, and fewer technicalities. The one sided theory of mental discipline must go. The general impression is abroad that mathematics is of little practical value, and the result has been its neglect and consequent loss of mathematical power on the part of the pupil. Our civilization craves action, and a subject that loses contact with life is doomed."

Mr. Trout, University of Denver, said: Do not hurry at the beginning. Avoid committing notes and definitions. Use various methods of demonstration. He emphasized that the instructor should give a careful analysis of the parts of a proposition and the proof, so that the pupil may know what is expected. He also showed the advantage of classifying propositions with respect to points to be proved.

Professor Alwyn C. Smith, Colorado School of Mines, suggested adopting methods for brief demonstration. He illustrated this point by the algebraic method. He said: Both in preparation by pupil, and presentation by teacher the algebraic method is easier because based on previous knowledge. Its use necessitates comparison, in order to adapt this method to the usual ones in the text, and so develops independent workers, and breaks up the tendency to memorize. This method assists in generalization, because the algebraic statement must be interpreted into words. It economizes time for both pupil and teacher in recitation and examination.

Supt. J. W. Ellison, Wheatridge, suggested the importance of our taking pupils as we find them, and that we cannot expect success for all. Pupils should memorize theorems exactly and demonstrations should never be written for class recitation.

Miss Ruby L. Carstens, University of Colorado, said that her experience showed that the classes of problems in solid geometry with which pupils had most difficulty were those which involved an algebraic solution and the loci problems. She thought the pupil could be greatly assisted in the beginning of solid geometry if the instructor exercised care in showing him the relation which exists between his plane and solid geometry—that he is simply enlarging his previous notions, in many instances replacing a point by a line and a line by a plane.

Miss Sabin, East Denver High School, said there never was any doubt in her mind as to the advisability of omitting a treatment of the theory of limits in plane geometry, but she did not feel sure that the treatment of limits should still be omitted when the pupil had reached his solid geometry.

Mr. Fitch, North Denver High School, suggested three ways of interesting a class. By wide application of the principle of continuity and duality. By multiplicity of demonstration. By observational geometry, in observing the geometric structure of animals like starfish, by observing the homes of animals like honeycombs, and the hexagonal forms of snow crystals.

Prof. S. L. Macdonald, State Agricultural College, said: The pupil has difficulty with solid geometry because he cannot visualize in three dimensions. He suggested the use of mathematical models to assist him in this respect.

Dr. O. C. Lester, University of Colorado, said, the pupils who come to him in the electrical courses are deficient in solid geometry because they know nothing of a solid angle. He illustrated the meaning of the term solid angle, and showed how to obtain its unit of measure.

For want of time, the general discussion was brief, but participated in by Prof. Ira M. DeLong, University of Colorado, and Prof. H. E. Russell, University of Denver, and others.

The Society adjourned to meet at the call of the officers.

GRACE E. SHOE.

Electric Hygroscope of Great Sensitiveness. J. Pionchon. Compt. rend. 146, 809.—A glass tube about 12 cm. long and 1.5 cm diameter is silvered inside and out to within about 1 cm. of one end. When such a tube is connected with a galvanometer and a source of electricity of about 100 volts no current passes through the circuit, but if that end of the tube where the silver coatings are separated by only the thickness of the glass be brought to within a few millimeters of the surface of a body emitting water vapor, the passage of the current is immediately indicated by the galvanometer. The sensitiveness of the hygroscope is such that not only the moisture emitted by the hand is detected but the difference in the amounts of moisture given off by different portions of the body as the back of the hand and the finger tip is readily shown.—H. M. S. Chemical Abstracts.

ARTICLES IN CURRENT MAGAZINES.

Astrophysical Journal. March, 1909: "The Complete Balmer Series in the Sodium Spectrum," by R. W. Wood; "On the Apparent Dispersion of Light in Space," by Peter Lebedew; "Spectroscopic Investigations on the Rotation of the Sun during the Year 1908," by Walter S. Adams; "Studies in Sensitometry," by R. J. Wallace and H. B. Lemon; "The Arc Spectrum of Iron from λ 6855 to λ 7412," by E. J. Evans; "The Arc Spectrum of Titanium from λ 5866 to λ 7364," by E. J. Evans; "The Mercury Paraboloid as a Reflecting Telescope," by R. W. Wood.

Conservation for March: "James Wilson, Secretary of Agriculture," by Thomas Elmer Will; "The Sacramento Valley," by Frederick Haynes Newell; "The Mangyanes: a Problem of Forest Protection," by Melvin L. Merritt; "The Conquest of the Colorado," by C. J. Blanchard; "Early Cuttings in the Lodgepole Pine Type of the Rocky Mountains," by E. R. Hodson; "Twenty-eighth Annual Meeting of the American Forestry Association," concluded.

Nature Study Review for March: "First Directory of Members American Nature Study Society."

Photo Era for April: "Pictorial Possibilities in Moving Pictures," C. H. Claudy; "On the Comparative Merits of Different Developers. II. Developers for Negatives," Malcolm Dean Miller; "The Instantaneous Flashlight and Its Uses," E. F. Keller; "Much in Little," Thomas H. Holmes; "Flower Photography," E. Louise Marillier.

Popular Science Monthly for April: "Life and Works of Darwin," Dr. Henry Fairfield Osborn; "The Individuality of Charles Darwin," Charles F. Cox; "Darwin and Geology," Professor John James Stevenson; "Darwin and Botany," Dr. Nathaniel Lord Britton; "Darwin and Zoölogy," Dr. Hermon C. Bumpus; "For Darwin," Professor T. H. Morgan; "Predarwinian and Postdarwinian Biology," Professor William Morton Wheeler; "The Halo of a Hundred Years," Professor R. M. Wenley; "The Origin of the Theory of Natural Selection," Dr. Alfred Russel Wallace; "The First Presentation of the Theory of Natural Selection," Sir Joseph Hooker; "The Progress of Science: Darwin Manuscripts; Portraits of Darwin; Celebrations in Honor of Darwin."

Physical Review for March: "Crystal Rectifiers for Electric Currents and Electric Oscillations. Part II. Carborundum, Molybdenite, Anatase, Brookite," G. W. Pierce; "Atmospheric Radio-activity in California and Colorado and the Range of the α-Particles from Radium B," Frederic A. Harvey; "Telephone Receiver Impedance," Roy T. Wells; "Proceedings of the American Physical Society." For April: "Colloidal Solutions, and the Refractive Indices of Gold, Platinum and Silver," B. J. Spence; "On the Bursting Strength of Glass Tubing," J. R. Roebuck; "The Temperature Coefficients of the Moving Coil Galvanometer," Anthony Zeleny and O. Hovda; "The Absorption and Reflection of Calcite and Aragonite for Infra-red Rays as Dependent upon the Plane of Polarization," R. E. Nyswander.

School Review for April: "Educational Reform and the Social Order," Charles W. Eliot; "Proposed Changes in the Accrediting of High Schools," C. P. Cary; "Need for a Comprehensive Restatement of Educational Theory," Jesse D. Burks; "Reform in the Teaching of Mathematics," Louis C. Karpinski.

School World for April: "Experimental Psychology and Education," J. A. Green; "The Teaching of Algebra," P. B. Ballard; "A School Course of Science Applied to Domestic Life," M. Wood.

Scientific American Supplement for March 20: "Wireless Telephony," Reginald Fessenden; "The Untilled Field of Chemistry," Arthur D. Little; "A Simple Metric Conversion Table," Walter T. Swingle. For March 27: "Wireless Telephony," Reginald Fessenden; "Joining Simplon with Loetschberg;" "The Ether of Space," Sir Oliver Lodge; "Solar Electric Phenomena." For April 3: "Edison's Inventions," Frank L. Dyer and T. C. Martin; "Experimenting with Plants and Animals," R. France; "Weeds that Are Used in Medicine," Emmet C. Hall. For April 10: "Edison's Inventions. II," Frank L. Dyer and T. C. Martin; "Commercial Production of Oxygen," Dr. Alfred Grademwitz; "Shrinking of the Earth's Crust," M. Eiden; "Hydroid Zoophytes," G. E. Bullen; "Flower Pigments," C. M. Broomall.

Weights and Measures for March: "Fourth Meeting of National Conference;" "Weights and Measures Legislation in Colorado;" "Dry Measures;" "Coal;" "Platform Scale Foundations."

QUALITATIVE AND QUANTITATIVE.

FRANKLIN T. JONES, UNIVERSITY SCHOOL, CLEVELAND.

In these days of discussion over the bugbear of "exact quantitative measurement," there seems to have been some confusion as to what a quantitative experiment is.

The pioneer physics experiments in this country were, as is well known, inspired by E. H. Hall of Harvard University, and the vast majority of laboratory experiments at the present time are merely a rewriting or modification of these experiments. Just now there is a considerable tendency to criticise these experiments as "fettering the secondary school teacher," encouraging "exact" measurements, and in general being the cause of any lack of efficiency in physics teaching. If these critics would do two things, a great light might come to them. (1) Read the Harvard pamphlet with the question continually in mind, How much emphasis does this particular experiment lay on exactness? (2) Write to the department of physics at Harvard University and ask if this or any other particular set of experiments is *obligatory*.

With respect to the second point, he will undoubtedly be surprised to receive a reply somewhat like this: "The Harvard list is not compulsory. Any reasonable list of experiments will be acceptable. We regret, however, that the laboratory examination must be based upon any 35 of the Harvard experiments." It is quite true that the last requirement makes many teachers think it necessary to stick to the Harvard list in order that their pupils may pass on the laboratory examination. In the case of some stupid students this is undoubtedly true, but any boy who has profited from his laboratory work can study the Harvard pamphlet for a week and stand far better than an even chance of passing. *It all depends on whether he works.*

The conclusion to be drawn is simply this: *Harvard College really leaves the teacher free to select his experiments to suit himself.* The same is true of other colleges that require entrance examinations. Many of the certificate colleges are less liberal.

With respect to emphasis on "exactness of measurement," the writer does not recall a single instance where the word "exact" appears. There is no calculation of "per cent of error" for any experiment. Most teachers will be surprised to learn that this bugbear is one which they have *voluntarily* introduced into school courses. The inference is clear—*they are free to do as they please with respect to exactness of measurement in laboratory exercises.*

Now, these exercises in the Harvard pamphlet represent *quantitative laboratory work* for the pupil. Without having consulted Professor Hall as to its correctness the writer will state his own inference as to the spirit of the pamphlet. It is simply this—*Qualitative results are frequently best obtained by quantitative means.* To illustrate: In the experiment on the heat of fusion of ice the important truth to be apprehended is that a large amount of heat is required to melt a small weight of ice. The numerical value of the heat of fusion adds the definiteness to the problem that holds the pupil's interest. Here

the qualitative result through the quantitative means is self-evident. Similar illustrations might be cited for almost the entire list of experiments.

The inquiry is perhaps pertinent: Are teachers who complain of "requirements" not objecting to fetters forged by themselves which they are at liberty to cast off when it suits their convenience?

DIVISION IN ARITHMETIC.

By S. A. Courtis, Detroit, Mich.

Believing that it was possible to give first grade children experience with the situations which call for operations with number in the later grades, a first grade teacher proceeded as follows:

Addition was called "combination." Two groups of objects were counted separately, *added*, by being placed in one group, and the sum found by counting the single group thus formed.

Subtraction was called "separation." The children, asked to subtract five stones from a group of seven stones, separated the seven stones into two groups, making one five stones, and counting the other to determine the size of the remainder.

Multiplication, in the same way, was carried out by the "combination of equal groups"; division by the separation of a group into equal parts.

An upper grade teacher approved of the work until it came to the division. To divide by two, the first grade teacher had permitted the children to separate a group of six dots *by two's* into three groups of two each, thus:

Undivided . . . . . .
Partially divided . . . . . .
Completely divided . . . . . .

The upper grade teacher insisted that this was dividing by three, and contended that dividing by two meant the separation of the group of six into two equal parts, thus:

Undivided . . . . . .
Divided . . . . . .

To support her position the first grade teacher brought forward the problem of "how many stamps at two cents each can be bought for six cents?" where the idea was plainly the separation of the six cents into groups of two cents each. The upper grade teacher came back with: "Six cents is divided equally among two children. How many cents did each one have?" in which the idea was plainly the separation of the six cents into two groups of three cents each. An outsider suggested that both were right, but this the teachers could not accept for what one called division by two, the other called division by three, and neither was willing to have the children taught that dividing by two was also dividing by three.

Who can straighten out the tangle and show the reasons for teaching the children one method, or the other, as a concrete representation of division by two? Also, who can suggest a reference to a book on number that would cover the point?

A DIRECT DEMONSTRATION.

By Sam T. Pickering,

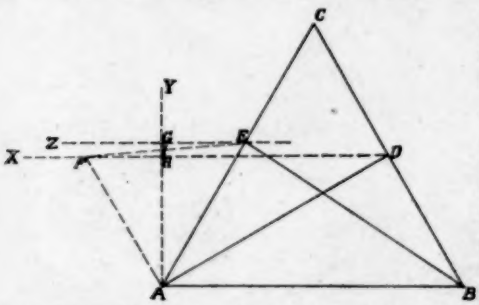
Junior in East High School, Cleveland, Ohio.

Proposition: If the bisectors of the base angles of a triangle are equal the triangle is isosceles.

Given: The triangle ABC, in which the bisectors, AD and BE are equal.

To prove: That the angle is isosceles.

Proof: Make angle XDA = angle EBA. Take DF = BA. Join AF. Triangles FDA and ABE are equal since: (FD = AB, AD = BE and angle FDA = angle ABE) ∴ AF = AE, and angle AFD = angle EAB. Through E draw EZ parallel to AB. Then angle ZEA = angle EAB, hence = angle AFD. Draw the bisector YA of the angle EAF, intersecting DF at H and EZ at G. Triangles FAH and EAG are equal since: (angle HFA = angle GEA, angle HAF = angle GAE, and AF = AE). ∴ FH = EG, and AH = AG. Join FE, intersecting AY at I. Right triangles HIF and GIE are equal since: [IF = IE, and HF = GE (angles HIF and GIE being right angles.)] ∴ angle IFH = angle IEG. ∴ DX is parallel to EZ, hence to AB. But, since H and G are identical, ∴ DX coincides with ZE and passes through E. ∴ angle DAB = angle XDA, hence = angle EBA. ∴ angle CAB = angle CBA. ∴ CA = CB. Q. E. D.



BOOKS RECEIVED.

The Appleton Arithmetics. by J. W. A. Young and L. L. Jackson; Primary Book, 1909, pp. 264, price, 35 cents; Grammar School Book, 1909, pp. 450, D. Appleton & Co., New York.

Beginners' Botany, by L. H. Bailey, 1909, pp. 208, The Macmillan Co., New York, price, 60 cents.

The Story Readers' Primer by May Langdon White, 1908, pp. 127, World Book Co., Yonkers, N. Y.

Library Bulletin, Kentucky Department of Education, 1908, pp. 74.

Kentucky Educational Directory, 1908-1909, J. G. Crabbe, Supt. Public Instruction.

It is hoped that our Biology readers will discuss freely the report of the New York Biology Committee which appeared in the February issue of this journal.

BOOK REVIEWS.

Laboratory Notes on Industrial Water Analysis, a survey course for engineers by Ellen H. Richards. 8vo. 52 pages. Cloth, 50 cents net. 1908. John Wiley & Sons, New York.

This excellent little manual is divided into two parts. Part I contains 5 laboratory exercises for about 30 hours' work in testing water for scale, hardness, solids, alkalinity, effect on metals, and remedies. In this short course only special methods are used, the ordinary analytical processes being omitted. Part II contains directions for making standard solutions, tables and a valuable list of reference books. This is a valuable and unique little book that should be on the desk of every chemistry teacher. C. M. T.

Applied Arts Drawing Books, by Wilhelmina Seegmiller. Price, ten cents for third and fourth grades; fifth, sixth, seventh, and eighth grades, fifteen cents. Published by Atkinson, Mentzer & Grover, Chicago.

This series of drawing books for the grades below the high school cannot help but impress one with the fact that the author has gotten together a list of designs, the quality of which has never before been published. The purpose of these books is not merely to teach children to draw, but to apply their ability along natural and useful lines; to teach them art not for art's sake but for its relation to their daily life. They also will assist the pupil as he goes out into life and begins to earn his own living. There are two parts to each book and each book is intended for a half year's work. The books are so arranged that the pages may be removed and used as art materials in construction work. There are numerous pages that may be used as color cards, calendar book covers, book marks, lamp shades, magazine holders, card cases, etc. The color work is of a high grade of art and probably has never before been approached in books of this character, selling for this extremely low price. There are over sixty color plates in the series. To produce these, cost the publishers much money. The pencil sketches have evidently been executed by an artist who understands his business. The books are well printed and well bound. In fact, they are gotten up in a very artistic manner, the mechanical work on them being of the very best. Schools contemplating introduction of this character of work would do well to communicate with the publishers. C. H. S.

Sanitation of Public Buildings, by William Paul Gerhard, C. E. $1.50. 260 pages. John Wiley & Sons, New York. 1907.

The information possessed by the general public on matters of the sanitary construction and care of public buildings has been obtained for the most part through suddenly discovered negligence or great catastrophes. We improve in our plans for saving the waste of existence first by wasting life prodigiously, and then sincerely regretting it; later we endeavor feebly to mend matters. Hospital epidemics, school and theater tragedies, and abattoir horrors have served their awful use of yielding bitter experience.

Mr. Gerhard's book, "Sanitation of Public Buildings," is not merely an exhortation to greater vigilance in preventing life waste. It does better by being a simple, common sense, untechnical but scientific exposition of how the requirements of public health can be observed in the construction of buildings where large numbers of people congregate. The book is divided into five chapters devoted to the hospital, the theater, the church, the school, and the market or abattoir.

Of these five types of public buildings, perhaps the least attention has been given formerly to the church building. We have had no great catastrophe or scandal on account of church buildings, to stir us to action against the lurking dangers of their air supply for heating, sewage disposal, ventilation, and disease germs in pew cushions. The author calls attention to the fact that the modern church building in the city is a great public institution whose activities frequently require equipment for toilet rooms, kitchens, serving pantries, gymnasia with baths and lockers. And yet, he says, sanitary or ventilating engineers are seldom consulted in the construction of these great meeting places.

The chapter devoted to school sanitation will be especially valuable in those regions of the country where technical advice of this kind seldom comes. The ignorance of the country builder and the frequent neglect of city architects may be rendered less dangerous by information possessed by a public increasingly intelligent about the safety of its school children. H. R. L.

Biology and Its Makers, Professor William A. Locy, Northwestern University. 469 pages. Published by Henry Holt and Company, New York.

The recent celebrations of the one hundredth anniversary of the birth of Charles Darwin, and the half centenary of the publication of "The Origin of Species," gives especial interest to Professor Locy's book upon "Biology and Its Makers."* Approximately three fourths of the book (Part I) deals with "The Source of Biological Ideas Except Those of Organic Evolution," the remaining fourth (Part II) dealing with "The Doctrine of Organic Evolution." Throughout the first part of the book the men who were prominent in each leading epoch of biological thought are treated biographically together with the presentation of the ideas that are characteristic of each epoch. The epochs treated cover the entire Christian era. Considering the scope in time and materials, and also that much space is given to biographical data and illustrations, it is evident that the author could treat only the most significant epochs and the men who have made the most distinct contributions to biological thought. Notwithstanding this gigantic field it is surprising how many men and how much detail find place within the compact paragraphs that compose the book.

There is a widespread need among general students for a resumé of the world's thought about nature problems. The evolution of biological thought is within itself one of the best illustrations of the method of evolution. In gathering the data concerning men, methods, and science problems and presenting these things in the form of a

complete account, Professor Locy has made usable and most attractive much material that formerly was inaccessible to most students of biology. O. W. C.

Principles of Breeding, A Treatise on Tremmatology, or, The Principles and Practices Involved in the Economic Improvement of Domesticated Animals and Plants. Eugene Davenport, University of Illinois. 727 pages. Ginn & Company.

The fact that new discoveries demand an increased intelligence on the part of those who would make use of them is well illustrated in a book entitled "Principles of Breeding."* Results of researches that do not find direct application in practical life do not create new duties for practical people. Studies upon the processes and factors in evolution of plants and animals have so direct a bearing upon improvement of domesticated forms that it becomes incumbent upon those who would breed plants and animals successfully, to understand present-day knowledge of these things. In this book attempt is made to recognize the tasks involved in improving plants and animals, to free these tasks from haphazard and unfounded guessing at results, and to "induce more exact methods of study and of practice than have hitherto characterized this branch of agricultural science." Although the author assumes the above problem as the one to be met by the book, in meeting it, it is necessary fully to discuss all important recent theories and experiments bearing upon biological evolution. Hence Part I of the book considers variation—morphological, substantive, meristic, functional, and mutational. In the second part of the book the causes of variation are treated in six chapters. Part III considers transmission under the chapter headings of "Transmission of Modifications Due to External Influences," "Type and Variability," "Correlation," "Heredity," and "Prepotency." Part IV consists of "Practical Problems," including chapters upon "Selection," "System of Breeding," "Determination of Sex," "Plant Breeding," "Animal Breeding and Development." An appendix prepared by Professor H. L. Rietz, of the Department of Mathematics of the University of Illinois, discusses "Statistical Methods," and presents numerous tables and calculations pertaining thereto.

It is to be assumed that the book was not written for popular reading, unless more general knowledge of botany, zoölogy, and physiology is assumed than is really possessed by the general reader. But as a readable assemblage of modern evolutionary thought and its possible and demonstrated applications to practical problems the book is easily the best that has been presented. If the younger generation of agriculturists attack their problems with the background of knowledge that this book makes possible, we may expect a very rapid advance in the practical aspects of evolutionary study. Furthermore the very large number of practical experiments that could be carried on by agriculturists would very greatly extend the general study of evolution itself O. W. C